THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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45-SECOND VOICE RECORDER MODULE

- ★ Record two, four or eight different messages
- ★ Clean and glitch-free line-level audio output
- ★ Can feed an amplifier or PA system
- ★ 8-bit recording quality, user-selected bandwidth

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PIR-TRIGGERED MAINS SWITCH

Use a domestic PIR system to switch any mains-powered device rated up to 10A

MULTI-FUNCTION, INTELLIGENT REMOTE-CONTROLLED DIMMER

The ultimate dimmer project using a standard handheld remote

Teach-In 2011 – Part 6

Logic circuits – Our not-to-be-missed introduction to gates and flip-flops

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APRIL 2011 PRINTED IN THE UK
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Low-Power Microcontrollers for Battery-Friendly Design

Microchip Offers Lowest Currents for Active and Sleep Modes

Extend the battery life in your application using PIC® microcontrollers with nanoWatt XLP Technology and get the industry's lowest currents for Active and Sleep modes.

Microchip's new peripheral-rich PIC12F182X, PIC16F182X and PIC16F19XX families offer active currents of less than 50 µA and sleep currents down to 20 nA. These products enable you to create battery-friendly designs that also incorporate capacitive touch sensing, LCD, communications and other functions which help differentiate your products in the marketplace.

Microchip's Enhanced Mid-range 8-bit architecture provides up to 50% increased performance and 14 new instructions that result in up to 40% better code execution over previous-generation 8-bit PIC16 MCUs.

PIC12F182X and PIC16F182X families include:

- Packages ranging from 8 to 64 pins
- mTouch™ capacitive touch-sensing
- Multiple communications peripherals
- Dual I²C™/SPI interfaces
- PWM outputs with independent time bases
- Data signal modulator

PIC16F19XX family includes:

- mTouch capacitive touch-sensing
- LCD drive
- Multiple communications peripherals
- More PWM channels, with independent timers
- Up to 28 KB of Flash program memory
- Enhanced data EEPROM
- 32-level bandgap reference
- Three rail-to-rail input comparators

GET STARTED IN 3 EASY STEPS

1. View the Low Power Comparison videos
2. Download the Low Power Tips 'n Tricks
3. Order samples and development tools
   www.microchip.com/XLP

PIC16F193X 'F1' Evaluation Platform - DM164130-1

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MICROCHIP

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• PROJECTS • THEORY •
• NEWS • COMMENT •
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VOL. 40. No 4 April 2011

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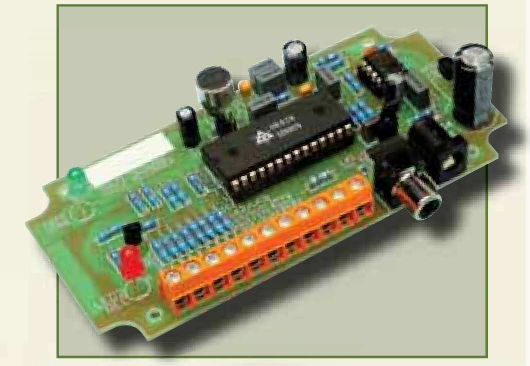


Projects and Circuits

Series and Features

Regulars and Services

Our May 2011 issue will be published on Thursday 14 April 2011, see page 80 for details.

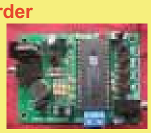
Hot New Products!

Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

4-Channel Serial Port Temperature Monitor & Controller Relay Board

4 channel computer serial port temperature monitor and relay controller with four inputs for Dallas DS18S20 or DS18B20 digital thermometer sensors (£3.95 each). Four 5A rated relay channels provide output control. Relays are independent of sensor channels, allowing flexibility to setup the linkage in any way you choose. Commands for reading temperature and relay control sent via the RS232 interface using simple text strings. Control using a simple terminal / comms program (Windows HyperTerminal) or our free Windows application software.
Kit Order Code: 3190KT - **£69.95**
Assembled Order Code: AS3190 - **£84.95**

40 Second Message Recorder

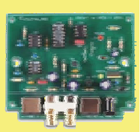


Feature packed non-volatile 40 second multi-message sound recorder module using a high quality Winbond sound recorder IC. Stand-alone operation using just six onboard buttons or use onboard SPI interface. Record using built-in microphone or external line in. 8-24 Vdc operation. Just change one resistor for different recording duration/sound quality. sampling frequency 4-12 kHz.
Kit Order Code: 3188KT - **£27.95**
Assembled Order Code: AS3188 - **£36.95**
120 second version also available

Bipolar Stepper Motor Chopper Driver

Get better performance from your stepper motors with this dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase set using on-board potentiometer. Rated to handle motor winding currents up to 2 Amps per phase. Operates on 9-36Vdc supply voltage. Provides all basic motor controls including full or half stepping of bipolar steppers and direction control. Allows multiple driver synchronisation. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£37.95**
Assembled Order Code: AS3187 - **£47.95**

Video Signal Cleaner



Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: K8036KT - **£32.95**
Assembled Order Code: VM106 - **£49.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

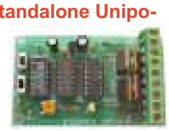
Motor Speed Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)

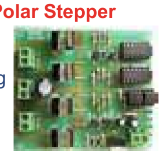
Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£18.95**
Assembled Order Code: AS3067 - **£26.95**

Computer Controlled / Standalone Unipolar Stepper Motor Driver



Drives any 5-35Vdc 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps. Provides speed and direction control. Operates in stand-alone or PC-controlled mode for CNC use. Connect up to six 3179 driver boards to a single parallel port. Board supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£15.95**
Assembled Order Code: AS3179 - **£22.95**

Computer Controlled Bi-Polar Stepper Motor Driver



Drive any 5-50Vdc, 5 Amp bi-polar stepper motor using externally supplied 5V levels for STEP and DIRECTION control. Opto-isolated inputs make it ideal for CNC applications using a PC running suitable software. Board supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£23.95**
Assembled Order Code: AS3158 - **£33.95**

Bidirectional DC Motor Speed Controller

Control the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£22.95**
Assembled Order Code: AS3166v2 - **£32.95**

AC Motor Speed Controller (600W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or 230V AC single phase induction motor rated up to 600 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - **£14.95**
Assembled Order Code: AS1074 - **£23.95**

See www.quasarelectronics.com for lots more motor controllers

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Order Code EPL500 - **£179.95**
Also available: 30-in-1 **£19.95**, 50-in-1 **£29.95,** 75-in-1 **£39.95** £130-in-1 **£44.95** & 300-in-1 **£69.95** (see website for details)

Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need.
Order Code: PCSU1000 - **£399.95**

Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal Scope is well suited for educational use.
Order Code: HPS10 - ~~£189.95~~ **£169.95**

See website for more super deals!

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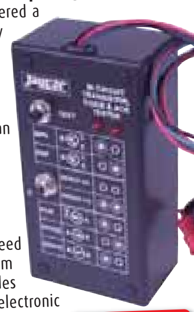
Test & Measurement Kits for Electronic Enthusiasts

KIT OF THE MONTH

Transistor Tester

KA-1119 £12.25 plus postage & packing

Have you ever unsoldered a suspect transistor only to find that it checks OK? Troubleshooting exercises are often hindered by this type of false alarm. You can avoid these hassles with the In-Circuit Transistor, SCR and Diode Tester. The kit does just that, test drives without the need to unsolder them from the circuit! Kit includes a jiffy box, battery, electronic components and a panel showing truth table for device checking.



CONSISTENT SELLER FOR OVER 25 YEARS!

CAR BATTERY MONITOR

KA-1683 £8.50 plus postage & packing

Don't get caught with a flat battery! This simple electronic voltmeter lets you monitor the condition of your car's battery so you can act before getting stranded. 10 LEDs tell you your battery's condition.

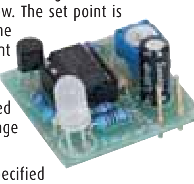
- Kit includes PC board and all components
- PCB Dimensions: 62 x 39mm

LED BATTERY VOLTAGE INDICATOR

KA-1778 £3.75 plus postage & packing

This tiny circuit measures just 25mm x 25mm and will provide power indication and low voltage indication using a bi-colour LED. The LED will be green when above the set point & red when below. The set point is adjustable using a trim-pot. The circuit is suitable for equipment powered from 6-30VDC. With a simple circuit change, the bi-colour LED will produce a red glow to indicate that the voltage has exceeded the value.

- PCB, bi-colour LED and all specified electronic components supplied



DIGITAL MULTIMETER KIT

KG-9250 £11.00 plus postage & packing

Learn everything there is to know about component recognition and basic electronics with this comprehensive kit. From test leads to solder, everything you need for the construction of this meter is included.

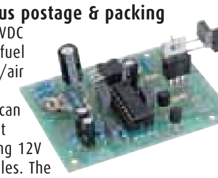
- Dimensions: 67(W) x 123(H) x 25(D)mm

10A DC MOTOR SPEED CONTROLLER

KC-5225 £11.50 plus postage & packing

Ideal for controlling 12VDC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. You can also use it for headlight dimming and for running 12V DC motors in 24V vehicles. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps. Includes PCB and all electronic components to build 10A version.

- PCB Dimensions: 69 x 51mm
- Output can increase to 20A with extra MOSFET available separately ZT-2450 £4.50

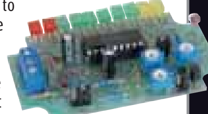


VOLTAGE MONITOR KIT

KC-5424 £10.75 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving.

- Kit includes PCB with overlay, LED bar graph and all electronic components.
- 12VDC
- Recommended box: UB5 use HB-6015 £1.25

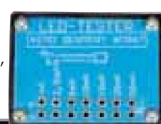


LED TESTER MODULE

AA-0272 £7.75 plus postage & packing

With this basic but essential tool it is possible to check the function, brightness, colour and polarity of all kinds of light emitting diodes (LED). The LED to be tested plugs into the front panel, at the current you wish to test it with. Two 10 mA positions have been included on this multi-LED tester so that comparisons between two LEDs can be made simultaneously.

- Requires 9V Bolt (not included)
- Test currents: 1mA, 2.5mA, 5mA, 10mA, 20mA, 50mA
- Dimensions: 58 x 44 x 25 mm



SLA BATTERY HEALTH CHECKER KIT

KC-5482 £29.00 plus postage & packing

The first versions of the battery zapper included a checker circuit. The Mk III battery zapper (KC-5479) has a separate checker circuit - and this is it. It checks the health of SLA batteries prior to charging or zapping with a simple LED condition indication of fair, poor, good etc.

- Overlay PCB and electronic components
- Case with machined and silk-screened front panel
- PCB Dimensions: 185 x 101mm

Don't just sit there BUILD SOMETHING!

WATER TANK KITS

PIC Based Water Tank Level Meter Kit

KC-5460 £46.75 plus postage & packing

This PIC-based unit uses a pressure sensor to monitor water level and will display tank level via an RGB LED at the press of a button. The kit can be expanded to include and optional wireless remote display panel that can monitor up to ten separate tanks (KC-5461) or you can add a wireless remote controlled mains power switch (KC-5462) to control remote water pumps. Kit includes electronic components, case, screen printed PCB and pressure sensor.

KC-5460

KC-5461

Also available:
KC-5461 - Remote display kit £36.50

Remote Control Mains Switch

KC-5462 £45.25 plus postage & packing

Commercial remote control mains switches are available but these are generally limited to a range of less than 20m. This UHF system will operate up to 200m and is perfect for remote power control systems etc. The switch can be activated using the included hand held controller.
Kit supplied with case, screen printed PCB, RF modules and all electronic components.

Note: Requires UK mains socket or adaptor

KC-5462

LOW CAPACITANCE ADAPTOR FOR DMM KIT

KC-5493 £15.25 plus postage & packing

Many modern multimeters come with capacitance ranges, but they're no good for very small values. This kit is a nifty little adaptor that allows a standard digital multimeter to measure very low values of capacitance from less than one picofarad to over 10nF. It will allow you to measure tiny capacitors or stray capacitances in switches, connectors and wiring. The kit is complete with PCB, components and case. All you'll need is a 9V battery and just about any modern DMM.

POST & PACKING CHARGES

Order Value	Cost
£10 - £49.99	£5
£50 - £99.99	£10
£100 - £199.99	£20
£200 - £499.99	£30
£500+	£40
Max weight 12lb (5kg)	
Heavier parcels POA	
Minimum order £10	

Note: Products are despatched from Australia, so local customs duty & taxes may apply.

- **All pricing in Pounds Sterling**
- **Minimum order £10**

Prices valid until 30/4/2011

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K5600R	Advertisement Li	
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K6002	Temperature Co	
K6003	Temperature Se	
K6200	0 to 60 Hours St	
K6400	Code Lock Kit	
K6501	Remote Control	
K6600	Multitone Chime	
K6712	IR Remote Contr	
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K8067	Universal Temperature Sensor K	
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K8070	1-Channel RF Receiver (for K805	
K8071	1W/3W High Power LED Driver	
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Handmade chips

I came across a fascinating story the other day that I would like to share with you. It demonstrates how far we've come since the emergence of the first microprocessor, the Intel 4004.

The 4004 made its debut in November 1971. Electronic News reported that it processed four bits of data at a time and ran at 108kHz (a ten thousandth of a gigahertz). It was originally designed to power an electronic calculator, but as we now know, it greatly exceeded the expectations of its designers and can rightly be considered the great grandfather of every single microprocessor we use today.

The detail that caught my eye was the design method, and by 'design' I mean the actual physical layout of the IC. Back then, of course, there were no PCs, workstations or nice autorouting software packages to draw neat, editable artwork. If you wanted to create the photolithography masks then you got out a pen, sketched the basics and then implemented them with a huge version of the chip made from masking film called Rubylith – 'ruby' because it was red and 'lith' for lithography, the photochemical etching process used to make integrated circuits. This huge sheet of film, which must have looked like a bizarre piece of modern art made out of red sellotape, was photographically reduced to make the final 1:1 design of the chip.

I remember making PCB designs using essentially similar methods at university, and the number of mistakes in the early stages was embarrassing to say the least. The thought of making a working microprocessor this way is extraordinary and a real testament to the skill and perseverance of those early Intel engineers.

Last, but not least, it demonstrates a nice virtuous circle of technological progress. It wasn't long before the computers made from early microprocessors took over this graphical job and helped speed up and improve the designs of the next microprocessors.

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NEWS

A roundup of the latest Everyday News from the world of electronics

Avid editing – updates by Barry Fox

Avid changed the face of professional video and movie editing, and now wants to do the same for consumer editing with the worldwide launch this spring of a 'completely new development' called Avid Studio. This puts Avid in direct competition with itself, because after a series of company acquisitions Avid now services 13 million worldwide users of the consumer editing software package, Pinnacle Studio. To harden the internal competition, Avid is launching new versions of the Pinnacle Studio just ahead of Avid Studio.

Through the 1990s, Avid's computer software moved the studio industry from cutting celluloid film to switching digital bitstreams. They bought Digidesign for its Pro Tools audio editing software, M-Audio for electronic musical instruments and Sibelius for computer scoring of all types of music. Avid acquired Pinnacle Systems in 2005 and is now releasing Version 15, with UK prices ranging between £60 and £100. Avid Studio follows in March, by download, and boxed for retail sale in April, at around £140.

Avid studio

'Avid Studio is a totally new category with a more modern feel. The engine has changed', says Wolfgang Schranz, European consumer sales manager. 'It's for Windows only, but there is no XP support; and there won't be a Mac version'.

It uses a new editing engine and new file format to get a different look and feel, and offers features that cannot be built into Pinnacle software. It was clear from pre-launch demonstrations given at Avid's European HQ in Pinewood Studios near London that the demonstrators were still getting to grips with the new software.

Key new features include an archiving option, which gathers all the source files from all sources, and collates them into a single archiving file; so a half-finished project can be completed later, or on the move, without the need to access all the original source file locations.

There is improved chromakey support for green screen effects, with a matching green backdrop boxed with the software. The user can create an unlimited number of audio and video tracks for building sound and vision effects.

Avid Studio can also create and mix 5.1 surround. Tracks can be imported from a 5.1 camcorder or created by editing and then exported as Dolby Digital 5.1 for DVD or Blu-Ray burning.

Neither Pinnacle Ver. 15 nor Avid Studio support 3-D editing.

Says Schranz, 'There is no 3-D support at the moment. We have it in our professional products, but at the moment we can't see a market for consumer software. Consumer 3D is at a very early stage. It is too early to see a clear trend. We cannot yet see a market for it. But, of course, we will listen to the market and react.'

Schranz admits that Avid now has a difficult marketing job on its hands, with 13 million Pinnacle users worldwide and none so far for Avid. 'Avid Studio is for aspirational users', he says. There will be an upgrade offering from Pinnacle to Avid, but the price is not yet fixed.

Pinewood celebration

Pinewood Studios, where Avid is based, is 75 years old this year. The controlling company now also owns Shepperton and Teddington studios in the UK and sister complexes in Berlin, Hamburg and Torronto. Pinewood started with four sound stages, and now has 34. The most famous is the huge 007 sound stage, where most of the Bond movies have been shot. Re-built after a fire in 2006, it now has a floor space of 59,000 square feet and is the largest in Europe.

Nearby, a stone-walled, open-air area the size of a football pitch can be flooded for sea sequences. It holds a million gallons and takes a week to fill and empty. A tall green screen wall at one end helped sink Venice in *Casino Royale*.

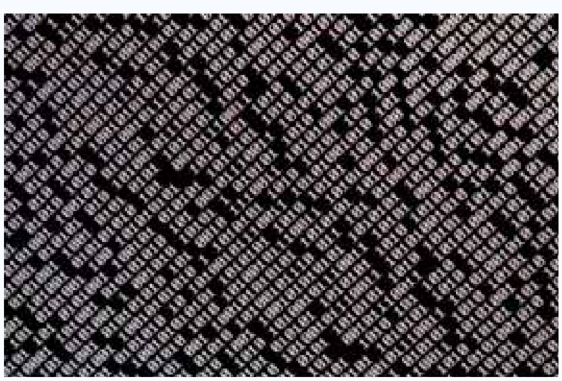
Nearby, the indoor underwater stage tank is six metres deep, with sets either built under water by divers or created with green screen effects. The tank is never drained, and the water kept clear and at a constant temperature of 32ºC. Filming is by underwater cameras in waterproof housings, operated by frogmen divers. Where fish are needed they are kept in a submerged tank. Despite advances in digital effects, under water live shooting is still routinely used because it is still hard to create a realistic wet effect on dry materials, hair and fabrics.

Unlike studios in Hollywood and Florida, Pinewood offers no public tours.

Data, data, data everywhere!

Our ravenous hunger for data, and the need to store it has been measured by researchers. A study, published in the journal *Science*, added up all the data stored in the world by 2007 and calculated 295 exabytes – an exabyte is a billion gigabytes, or a trillion megabytes.

The researchers reached this figure by estimating the amount of data held on 60 technologies, from PCs and DVDs to paper adverts and books. They calculated that if this information was stored on CDs then it would produce a pile of discs that would extend to beyond the moon.



The data survey covered the 'information revolution', when societies moved into the digital age, swapping 'analogue formats' such as compact cassettes, and traditional print for digital music and the Internet.

The rate of change in the move to digital storage has been rapid. In 2000, 75% of stored information was still in an analogue format, such as video cassette tape. However, by 2007, 94% of it was digital. The study pinpoints the arrival of the digital age at 2002, the first year when digital storage capacity overtook analogue capacity.

Not surprisingly, the biggest source of all these ones and zeroes is digital computing.

Nokia calls Microsoft

Nokia President and CEO Stephen Elop (left) links up with Microsoft CEO Steven Ballmer

Once the undisputed leader of mobile phone technology, Nokia has found itself in retreat for the last couple of years. The key problem for Nokia lies in the lucrative 'smartphone' market, where much of the industry's growth and profit is found. Newcomers Apple, with their iPhone and Google's increasingly popular Android mobile operating system have caused the Finnish mobile giant to look for strategic partners.

Nokia still makes a third of all mobile phones sold worldwide, but took just 12% of profits in the fourth quarter of 2010. Apple, on the other hand, shipped only 4% of devices to the mobile market, but achieved an extraordinary 50% of all profits. Not bad for a company that hadn't even sold a phone till 2007.

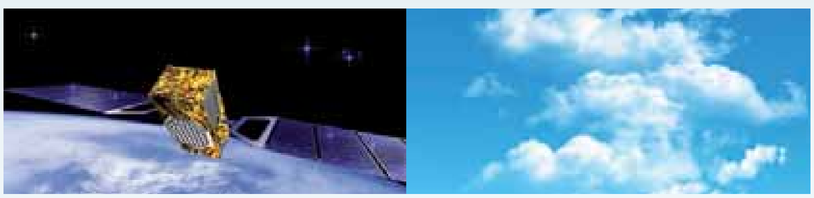
As if the threat from Apple was not bad enough, Nokia now faces stiff competition from devices running Android, which runs on a third of all smartphones sold at the end of 2010. Nokia's phones currently use the Symbian operating system, which has proved much less popular than those from either Apple (iOS) or Google.

To get back into the smartphone race, Nokia has turned to Microsoft, and together they have announced plans to form a broad strategic partnership that would use their complementary strengths and expertise to create a new global mobile ecosystem.

Nokia and Microsoft intend to jointly create mobile products and services. Under the proposed partnership:

- Nokia will adopt Windows Phone as its principal smartphone strategy, innovating on top of the platform in areas such as imaging
- Nokia will help drive the future of Windows Phone, contributing its expertise in hardware design, language support, and help bring Windows Phone to a larger range of markets
- Microsoft's Bing will power Nokia's search services across Nokia devices and services
- Nokia Maps will be a core part of Microsoft's mapping services. For example, Maps will be integrated with Microsoft's Bing search engine and adCenter advertising platform to provide local search and advertising
- Microsoft development tools will be used to create applications to run on Nokia Windows Phones

Businesses thrive with clouds and satellites



It is no surprise to learn that digital technology plays an important role in business, but two areas that are especially important play an unexpectedly large role in driving commerce across developed economies.

A report on the BBC revealed that 6% to 7% of EU GDP depends on satellite navigation. Using an American study, and extrapolating the results to the European economy, the EU Commission has estimated that 800bn euros of business directly uses satellite navigation. The industrial sectors most reliant on sat-nav technology are:

Delivery services rely on GPS nearly 100% because fleet management and parcel tracking by sat-nav is used by all freight forwarders and couriers.

Utilities and their transmission and distribution networks (eg, electricity grids) rely on sat-nav timing for synchronisation.

Banking and finance, where up to a third of this type of business uses the accuracy of GPS time to 'time stamp' big transactions.

Agriculture increasingly depends on GPS in areas such as 'precision agriculture', where field management (eg, spraying or harvesting) on large European farms is carried out with the assistance of GPS in the tractor or the cabin of a combine harvester.

Communications systems in the form of smartphones almost universally include a GPS chip, for which a host of uses from basic map reading to locating a new restaurant are becoming more and more popular.

Cloud computing

For IT decision makers, cloud computing is increasingly creating new business opportunities. In this case, the clouds are most definitely not water-based, but offsite servers that store and back-up software and data, and provide computational power. All a user needs is an ordinary Internet-linked PC to access much more powerful and robust computational resources.

In a survey carried out by Microsoft, IT planners in financial services, manufacturing, professional services, and retail and hospitality saw cloud computing as an opportunity to grow their business, drive innovation and strategy, and efficiently collaborate across geographies. The key in all these examples was allowing access to data from anywhere.

Microsoft found that cloud computing has two big advantages: it lets small businesses act like big businesses, giving them the opportunity to use IT resources that might otherwise be beyond their budgets; and it lets big businesses move quickly and cheaply with the speed and nimbleness of a small business. For big businesses, there is also an opportunity to innovate at a lower cost with multiple options rather than having to sink all of their chips into a single, big capital cost option.

'Clouds' are not just for businesses, big or small. Companies such as Apple offer a cloud-based system for individuals, which lets users access their email, calendar/diary, address book, photo collection and other resources from any Internet-connected computer. Apple's Mobile Me is available on an annual subscription basis: £45 for an individual user and £76 for a family pack.

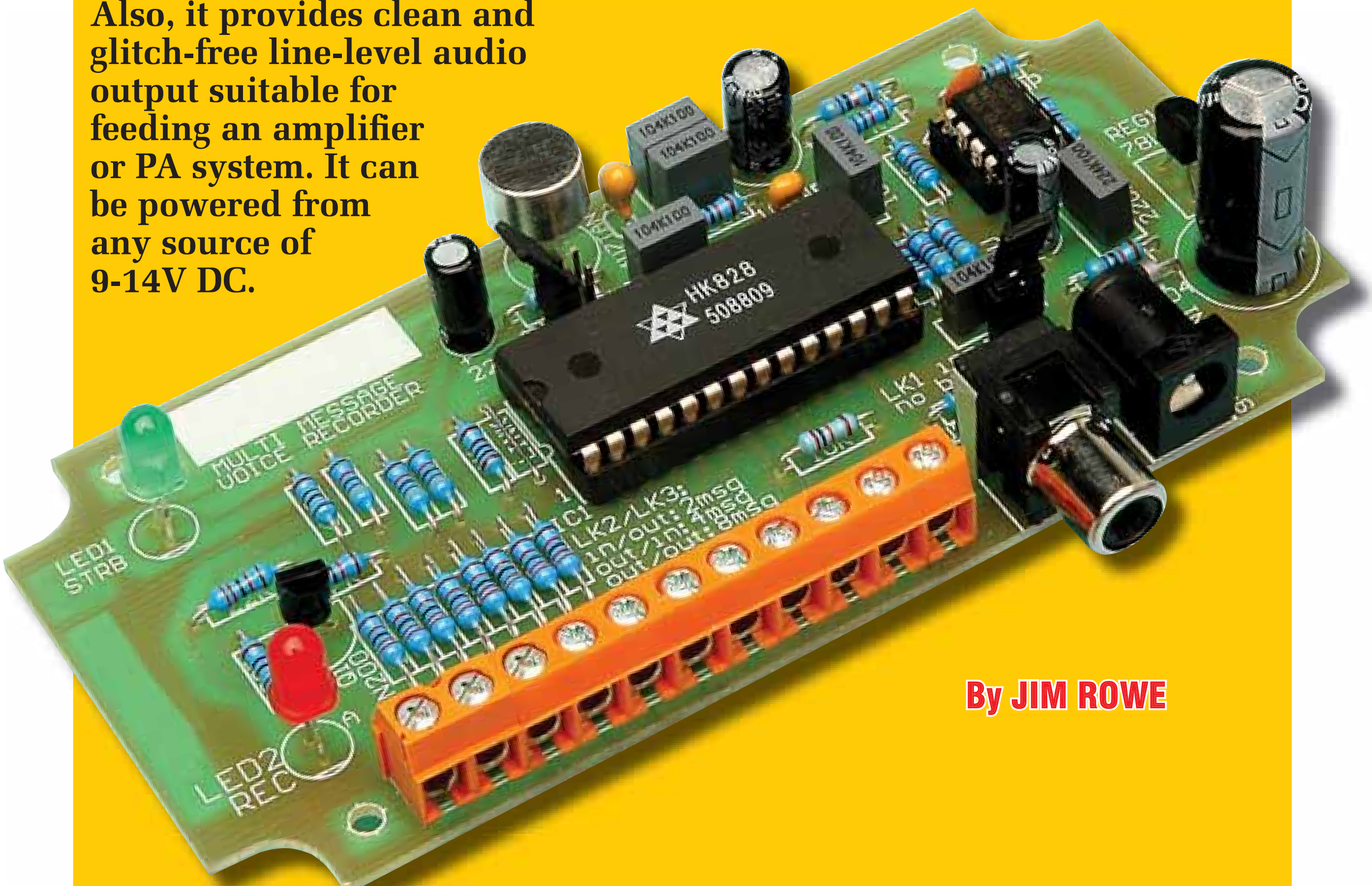
Smart projection

STMicroelectronics and bTendo Ltd have announced that they will jointly develop the world's smallest 'pico projector' for smartphones and other portable consumer-electronics devices. The solution is based on bTendo's innovative scanning laser projection engine technology and ST's MEMS (micro-electro mechanical systems) expertise, video processing know-how and semiconductor process technology.

The large memory capacity of today's advanced smartphones means that people carry huge amounts of movie clips and photos in their pockets, yet find it difficult to share it with others due to phone's tiny displays. Adding projection capabilities into the mobile devices will enable users to easily share their media with others – any place, on any surface, at any time.

Less than 2.5cm^3 in volume and under 6mm high, the jointly developed embedded projector will offer a focus-free, vivid, sharp and crisp image, superior to current pico projection solutions. Implementing two MEMS-based micro-mirror-actuation devices within the system's optical engine, and an advanced video-processing chip, the world's smallest projection engine will be optimised for smart phones, offering low power consumption and built-in support for MIPI (mobile industry processor interface) to ensure swift and easy integration.

Here's a voice recorder design that can be set up easily to record two, four or eight different messages for random-access playback or a single message for 'tape mode' playback. Also, it provides clean and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9-14V DC.



By JIM ROWE

45-second Voice Recorder Module

SOLID-STATE voice recorders are popular projects. They can be used in all sorts of applications where messages or sounds need to be recorded and played back reliably under either manual or micro control.

Such projects often have annoying limitations – for example, they can only be used to record and play back one long message or a number of short messages in sequential 'tape recorder' fashion. Such design limitations are often unnecessary, because the recorder chips used are typically capable of recording and playing back up to eight messages in 'random access' mode.

Another common limitation is that the playback sound quality can be fairly noisy, and each message played might be accompanied by an irritating 'click' at the start and finish.

Reader feedback revealed another limitation: older modules have been designed to operate from a 6V battery, whereas many people wanted to use a nominal 12V DC source.

Design concept

It was with these limitations in mind that we decided to develop the sound recorder module described here.

It's based on the HK828 chip, with the rest of the circuit designed to allow flexibility in terms of message storage and to provide much cleaner and click-free playback audio. Finally, the circuit can run from any source of DC between 9V and 14V.

The HK828 chip has the ability to store single or multiple messages with a total length of between 40 and 60 seconds, depending on the sampling rate and the voice quality you want.

In this recorder module, the chip is teamed up with a low-cost electret microphone insert to allow easy message recording, plus an LM358 dual op amp IC, which allows the recorded messages to be played back as a line-level audio signal, available for feeding an external amplifier and speaker.

Getting the message

We've given this module a set of 'jumper links', so that it can be easily configured to record and play back messages in any of four modes: either two, four or eight messages in random access mode, or one or more messages in sequential access 'tape mode'. Another link allows the HK828 chip's message start 'beeps' to be enabled or disabled, as you wish.

All message selection, record and play functions are controlled externally, via connections to a row of screw terminals along the side of the module. All functions are enabled by switches or logic signals.

This makes it easy to record or play back messages using a set of pushbuttons and a switch, or under the control of a PC, microcontroller or security system if you prefer.

The HK828 voice recorder chip is available from Jaycar Electronics in the UK (see their advert in this issue), and kits for the recorder module will also be available from them (Cat. No. KC5454).

How it works

The HK828 chip forms the functional heart of the recorder module, therefore you need to have a rough idea of what goes on inside this chip in order to understand how the recorder works. Fig.1 shows the chip's basic architecture.

First, the chip includes a high-gain microphone preamp so that it can be driven directly by a low-cost electret microphone insert. An automatic gain control (AGC) circuit follows the preamp, to ensure that good quality recordings can be made without any need for manual gain adjustment, despite input signal level variations.

The output of the AGC circuit is not connected directly to the chip's recording circuitry, but is brought out to the 'Aout' pin instead. This is linked to the 'Ain' pin by the user, to record messages from the microphone. This arrangement allows the chip to be used to record from line-level signals in other applications.

Since the main part of the HK828 records by a process of sampling the audio signals fed into it via the Ain pin, it needs to pass these signals through a low-pass filter before the sampling. This is done to prevent distortion caused by sampling aliases, hence the 'anti-aliasing' filter between the 'Ain' input and the sample and hold circuit block.

Now, although the audio is sampled inside the HK828, this is done using an analogue sample-and-hold system, rather than the more common digital

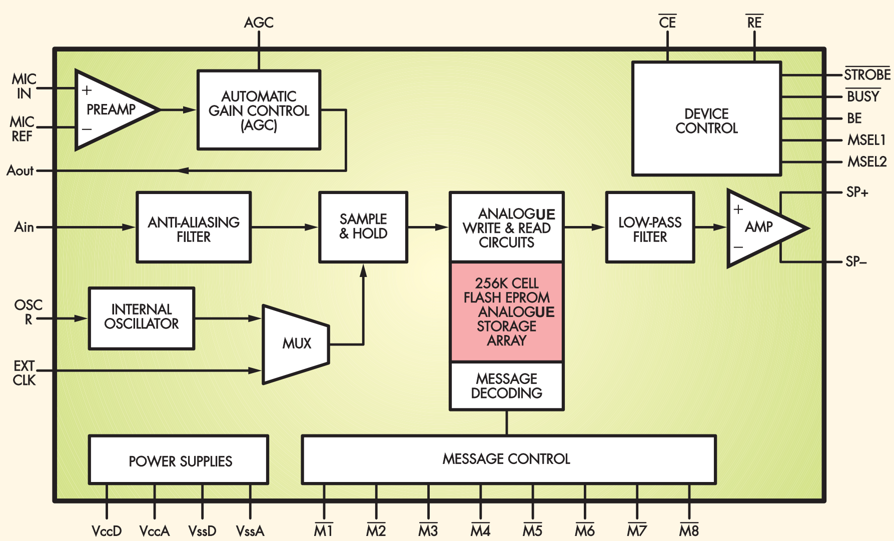


Fig.1: the block diagram of the HK828 voice recorder chip. While the recording process relies on audio sampling, the audio is not stored digitally, but uses an analogue sample-and-hold system. The analogue samples are stored in the cells of a 256K Flash EEPROM. Each analogue storage cell can store any of 256 different voltage levels, making it equivalent to an 8-bit digital recording.

sampling system. It stores the samples in an array of 262,144 (256K) Flash EEPROM analogue storage cells, each of which can store any of 256 different voltage levels. This gives the equivalent of 8-bit digital recording.

Sampling rate

The capacity of the storage array means that the HK828 can store a total of 256K samples. How long a recorded message this gives depends on the sampling rate that's used.

For example, if the sample rate is 8000 samples per second, 256K samples will correspond to a total message length of just over 32 seconds (262,144/8000). However, if you sample at 4200 samples/second, the 256K samples will give a total message length of just over 62 seconds (262,144/4200).

The recording bandwidth or 'fidelity' is directly proportional to the sampling rate. So, if you sample at 4200 samples/second, the recording bandwidth will be just over 2kHz, whereas sampling at 8000 samples/second gives a bandwidth of just on 4kHz.

Choosing the sampling rate is therefore a compromise: the lower the sampling, rate the longer the recording time, but the lower the audio bandwidth. Conversely, the higher the sampling rate the higher the bandwidth, but the shorter the recording time.

The HK828 chip has an internal sampling rate clock oscillator, as well as an input for an optional external clock. Either clock signal can be fed to the sample and hold circuit via the multiplexer (MUX), to control the sampling.

The frequency of the internal oscillator is set by varying the value of an external resistor connected between the 'OscR' pin and ground. This circuit uses a 47kΩ resistor, which sets the sampling rate to about 5800 samples/second. This gives a message recording time of about 45 seconds and a bandwidth of about 2.9kHz, for reasonable voice-quality recording.

As shown in Fig.1, the recording and playback of samples in the storage array is controlled by analogue write and read circuits, along with the message control and message decoding circuits. When a message is being played back, the signals pass through another low-pass filter to remove sampling noise, and are then fed to the inbuilt output amplifier.

The rest of the circuitry inside the HK828 chip is used for overall device control, mode switching and so on.

Circuit details

The complete circuit details for the Multi-Message Voice Recorder is shown in Fig.2.

As shown, signals from the electret microphone insert are coupled into the MICin input of the HK828 (pin 17) via a 100nF coupling capacitor. Another 100nF capacitor is used to tie the preamp's second MICref input (pin 18) to ground, to provide maximum gain.

The 4.7µF capacitor and 220kΩ resistor connected between pin 19 and ground are used to optimise the chip's AGC attack and decay characteristics for speech. The amplified audio from the mic preamp and AGC circuit appears at pin 21 (Aout), which is coupled directly to pin 20 (Ain) via another 100nF capacitor.

As mentioned earlier, the internal sampling oscillator frequency is set to 5.8kHz by the 47kΩ resistor connected to ground from pin 7 (OscR).

Setting the HK828 into record or playback modes is achieved by an external switch or logic signal connected to the $\overline{\text{RecEnable}}$ terminal, which connects to the chip's $\overline{\text{RE}}$ pin (27).

The terminal is pulled to ground for record mode or allowed to rise to logic high level (+5V) for playback mode. Note that when the terminal is pulled down to ground for record mode, this also allows transistor Q1 to draw base current and turn on – allowing current to flow through LED2, the record mode indicator.

Link LK1 is used to enable or disable the HK828's message-starting 'beep', by changing the logic level at pin 11 ('Beep Enable'). Similarly, links LK2 and LK3 are used to set the desired message recording and playback mode, as shown in the small table on the circuit diagram.

Message recording

To record a message in one of the random access modes, all that needs to be done is to pull down the $\overline{\text{RecEnable}}$ line to force the chip into recording mode, and then pull down one of the message-select lines (eg, $\overline{\text{M1Enable}}$ or $\overline{\text{M2Enable}}$) using an external push-button or a logic signal from a PC or microcontroller.

The message select line must be held down for the duration of the message

Parts List – Multi-message Voice Recorder

1 PC board, code 797, available from the *EPE PCB Service*, size 119mm × 57mm
1 electret microphone insert
3 3-way terminal blocks, PC mounting
1 2-way terminal block, PC mounting
3 2-pin sections of SIL header strip
3 jumper shunts
1 28-pin DIL IC socket, 15.24mm spacing
1 8-pin DIL IC socket, 7.62mm spacing
1 2.5mm concentric DC power plug, PC mounting (CON1)
1 audio phono socket, PC mounting (CON2)

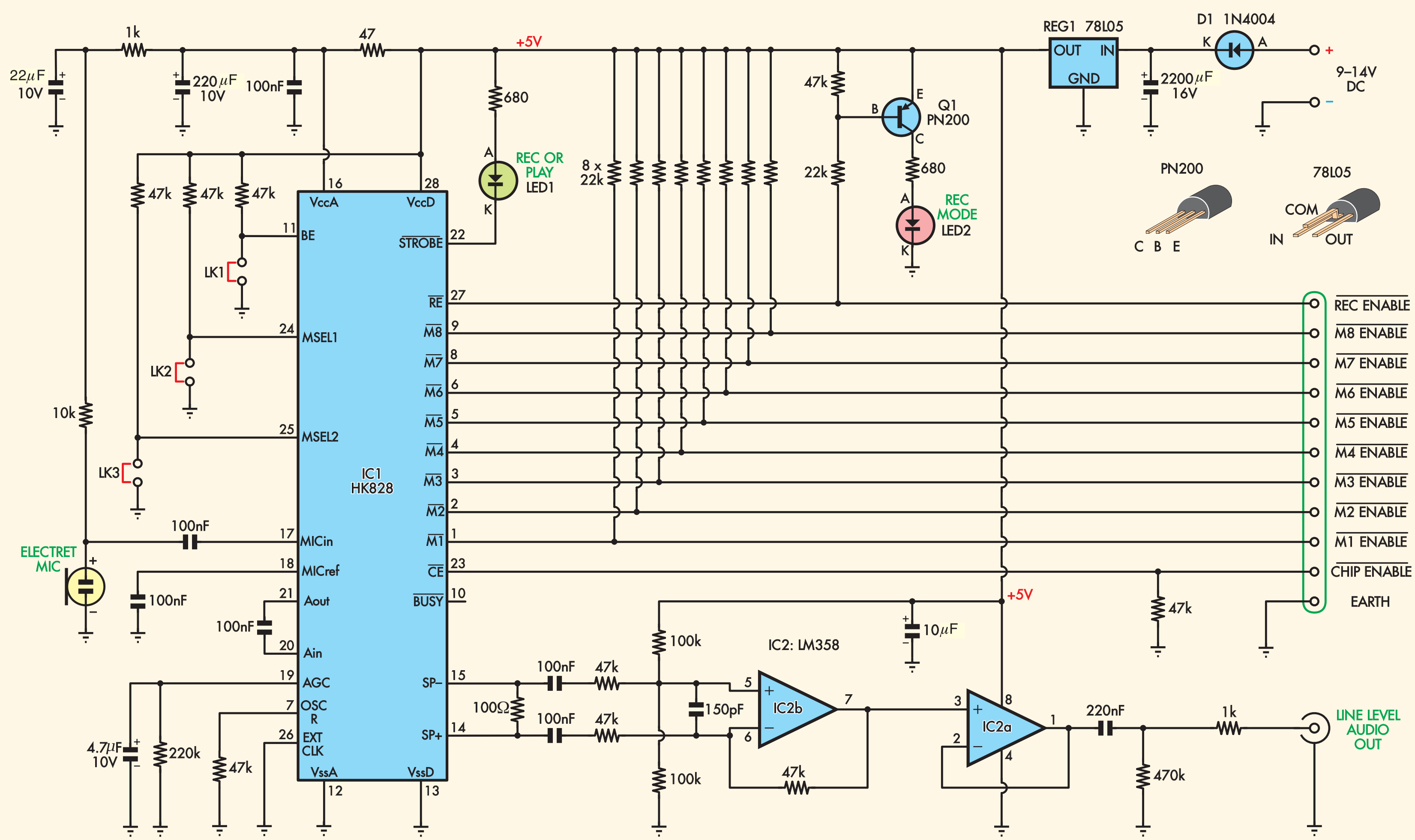
Semiconductors
1 HK828 voice recorder IC (IC1)
1 LM358 dual op amp (IC2)
1 78L05 +5V regulator (REG1)
1 PN200 *PNP* transistor (Q1)
1 5mm green LED (LED1)
1 5mm red LED (LED2)
1 1N4004 1A diode (D1)

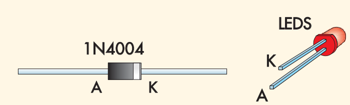
Capacitors
1 2200µF 16V radial elect.
1 220µF 16V radial elect.
1 22µF 16V radial elect.
1 10µF 16V radial elect.
1 4.7µF 25V tag tantalum
1 220nF 100V MKT metallised polyester
5 100nF 100V MKT metallised polyester
1 100nF multilayer monolithic ceramic
1 150pF disc ceramic

Resistors (0.25W 1%)

1 470kΩ	1 220kΩ
2 100kΩ	8 47kΩ
9 22kΩ	2 10kΩ
2 1kΩ	2 680Ω
1 100Ω	1 47Ω

Where from?
A kit is only available from Jaycar Electronics, who also hold the copyright on the design and PC board.
Kits will be available from Jaycar Electronics (Cat no KC-5454).





LINK1: IN = BEEP DISABLED
OUT = BEEP ENABLED

MULTI-MESSAGE VOICE RECORDER

LK2	LK3	OPERATING MODE
IN	OUT	2 MESSAGES, RANDOM ACCESS
OUT	IN	4 MESSAGES, RANDOM ACCESS
OUT	OUT	8 MESSAGES, RANDOM ACCESS
IN	IN	(TAPE MODE)

Fig.2: Most of the circuit action takes place in the HK828 voice storage chip (IC1). IC2, the LM358 dual op amp, performs a balanced-to-unbalanced conversion of the output from the HK828 and then provides a buffered output which can be fed to an audio amplifier and loudspeaker.

recording; recording ends when the line is allowed to rise high again.

To play the recorded message, the RecEnable line is allowed to rise high again, and the message select line for the message you want to replay pulled down again for about 400ms.

The playback audio emerges in push-pull (ie, anti-phase) fashion from pin 14 and pin 15 of the HK828, the SP+ and SP– pins, and is connected to a 100Ω load resistor. The signals are fed via 100nF capacitors to a balanced-to-unbalanced matching stage using IC2b, one half of an LM358 dual op amp.

This effectively adds the two signals together, and cancels out the 'common-mode pedestal' signal that appears with them on both outputs.

As a result, the output audio signal at pin 7 of op amp IC2b is clean and 'glitch free'. This is then passed through op amp IC2a, connected as a voltage follower/buffer and then fed to the line-level audio output socket.

All of this part of the circuit operates from +5V DC from REG1, an LM78L05 regulator. We are able to use a low power regulator because the total current drain is quite low: about 4mA in standby mode, rising to about 45mA when a message is actually being played or recorded.

There's one remaining point which should be mentioned about the circuit. You'll note that the HK828 chip is provided with a ChipEnable pin (pin 23), which in this circuit is pulled down to earth via a 47kΩ resistor – so the chip is enabled by default. However, the ChipEnable line is also brought out to a terminal, to allow you to apply a logic high (+5V) to this

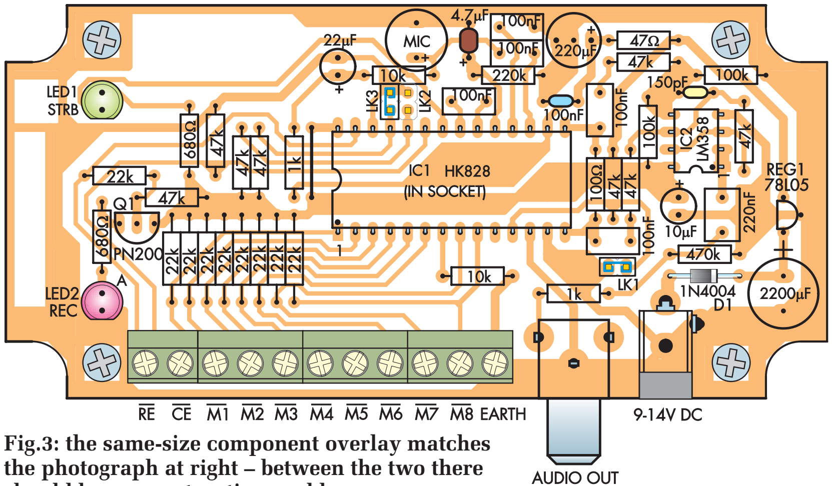


Fig.3: the same-size component overlay matches the photograph at right – between the two there should be no construction problems.

line if you want to disable the chip for any reason. You might want to do this if you have a microcontroller or PC controlling a number of the modules, in which case it will need to be able to select between them using their ChipEnable lines.

Construction

All of the components used in the Voice Recorder module fit on a compact PC board, coded 797, measuring 119mm × 57mm. This board is available from the *EPE PCB Service*. The board can be mounted inside a standard UB3-size plastic box.

Since all of the screw terminals and connectors are along one side of the board, they will all be accessible via a slot or series of holes along that side of the box. Only three holes will be needed in the box lid: two 5mm holes for LED1 and LED2, and a larger hole to allow sound to reach the electret mic insert.

The location and orientation of all components on the board can be seen in the overlay diagram of Fig.3, and also in the matching photo of the module.

Start board assembly by fitting the four screw terminal blocks, then the DC input and audio output sockets. Follow these with the two IC sockets, the three 2-pin headers for links LK1 to LK3 and the short wire link, which fits just near the end of the 28-pin IC socket. After this, you can fit the resistors and smaller non-polarised capacitors.

Next come the 4.7µF tantalum and the electrolytic capacitors, which are all polarised, so make sure you fit them with the orientation shown in the diagram.

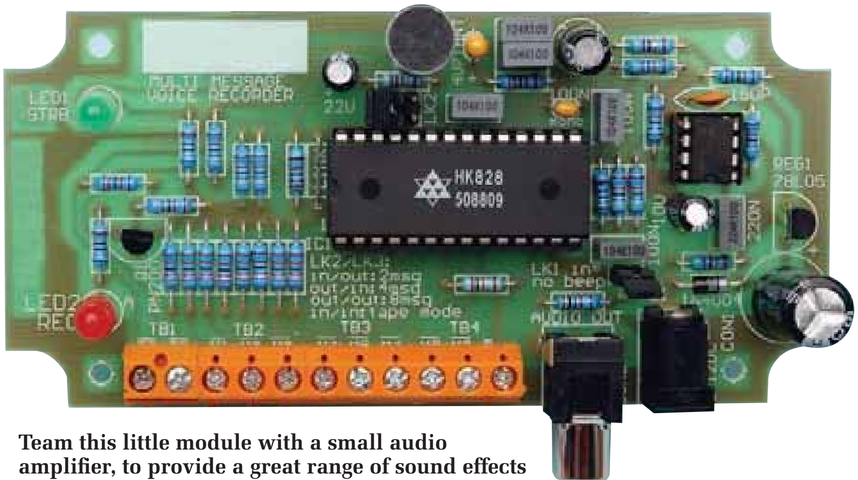
Now you'll be ready to fit the semiconductor parts. These are also polarised, so make sure you follow the diagram carefully as a guide to their orientation. Fit diode D1 first, then transistor Q1 and the two LEDs, followed by regulator REG1.

Now fit the electret mic insert. This has only two wire leads, but it is polarised, so do check the back of the insert to make sure which lead connects to the metal body of the insert. This is the negative lead, which must be connected to the 'earthy' outer pad under the board. The other lead is the positive lead.

Finally, plug the LM358 op amp IC2 into its 8-pin socket and the larger HK828 chip IC1 into its 28-pin socket. Make sure they're both orientated as shown in Fig.3. Your

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow purple yellow brown	yellow purple black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	8	47kΩ	yellow purple orange brown	yellow purple black red brown
❑	9	22kΩ	red red orange brown	red red black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	2	680Ω	blue grey brown brown	blue grey black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	47Ω	yellow purple black brown	yellow purple black gold brown



Team this little module with a small audio amplifier, to provide a great range of sound effects for a model railway layout, for example. It has the ability to store up to eight different 'sound grabs', which could be switched to different parts of the layout as trains pass through stations.

Multi-Message Voice Recorder should now be complete and ready to go.

Trying it out

To check that your recorder is working correctly, first decide which message mode you want to use it in, and then place jumper shunts on link headers LK1, LK2 and LK3 to set the module for that mode of operation. (Use the Table in Fig.2 as a guide.)

Connect a small toggle switch and one pushbutton switch (for each message you want to select) to the appropriate screw terminals of the module, as shown in Fig.4. For now, switch the toggle switch off, which corresponds to message playback mode.

The audio output of the module can now be connected to the line input of any suitable audio amplifier. Then you can connect its DC power input to a source of 9V to 14V DC.

At this stage, neither of the LEDs should light, but you may hear a small turn-on 'plop' from the speaker connected to the external amplifier. If you wish you can use a digital multimeter to confirm that the supply voltage at pin 8 of IC2 is very close to +5V, relative to the module's earth terminal.

Capacitor Codes

Value	µF Code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
150pF	n/a	150p	151

Now switch the external toggle switch on, pulling the $\overline{\text{RecEnable}}$ line down to earth potential. This should switch the module into Record mode, so LED2 should begin glowing. (If it doesn't begin glowing, you either have the DC power polarity reversed, or LED2 fitted to the board the wrong way around.)

Record/replay

Next, press one of the message select pushbuttons – say MSG1 in Fig.4. While holding it down, begin talking into the electret mic to record your test message.

As you speak, you'll notice that the green Strobe LED (LED1) is flashing. Keep talking until you reach the end of your message or until LED1 stops flashing (which indicates that recording has stopped automatically, because you have reached the end of that segment of the HK828's memory). Then release the pushbutton.

To replay the recorded message, turn the toggle switch off to swing the module into Play mode and briefly press the message pushbutton again, but this time only briefly because in Play mode, the message buttons only trigger the replay operation.

Your recorded message should then be replayed through the external amplifier and speaker. If it does, your Multi-Message Voice Recorder is working correctly and should now be ready for use.

Changing message length

As mentioned earlier, the total message length stored in the HK828 chip's memory is determined by the sampling rate, which is set by the resistor connected from pin 7 of the chip (OscR) to ground.

The 47kΩ value shown for this resistor in the circuit and overlay diagram gives a sampling rate of 5800 samples/second, resulting in a total message length of 45 seconds and an audio bandwidth of about 2.9kHz.

We picked this as a reasonable compromise between message length and recording quality, but you can experiment with the value of this resistor to try longer/shorter recording times and narrower/wider audio bandwidth.

For example, if you change the resistor value to 82kΩ, this will lower the sampling rate to about 4200 samples/second and give a total recording time of just on 60 seconds. However, the audio bandwidth will also drop to around 2kHz, so the played-back message(s) will sound rather 'muffled' – a bit like talking through a wet sock!

On the other hand, if you lower the resistor value to 24kΩ, this will increase the sampling rate to about 8000 samples/second and drop the recording time to just on 32 seconds. However, the recording quality will improve, as the audio bandwidth will increase to about 4kHz.

So, experiment by all means, and settle on the resistor value you decide gives the best combination of total message length and acceptable audio quality for your application.

Changing message mode

As noted earlier, header links LK2 and LK3 on the board can change the module's message access mode.

For example, with a jumper shunt fitted to LK2 but removed from LK3, the module will be able to record and play two messages (each using half the HK828's memory space).

You'll only need two external pushbuttons to select one of these messages: MSG1 and MSG2, along with the Record/Play toggle switch.

If you want to record and play four messages, remove the jumper shunt from LK2 and place one on LK3 instead. You'll now need four external pushbuttons as well as the Record/Play toggle switch: MSG1, MSG2, MSG3 and MSG4. Note that in this case, each message will be able to use one quarter of the HK828's memory.

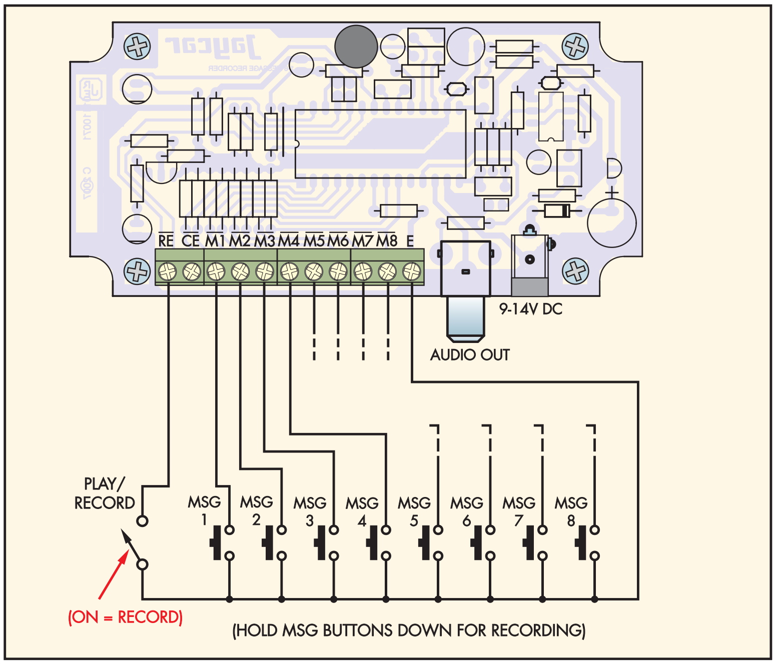


Fig.4: Staying with the model rail theme, you could use reed relays or other switches to play back the sound grabs when the train triggers them or they are switched by the operator. If the sound grabs are played in different locations, you will need additional speakers and relays to switch them to the amplifier.

Leave the jumper shunts off both LK2 and LK3 if you want to record and play any of eight short messages (each using one eighth of the HK828's memory). You'll now need all eight external pushbuttons MSG1 to MSG8, along with the Record/Play toggle switch.

The last option is to fit jumper shunts to both LK2 and LK3, which sets the module for 'tape mode' operation.

In this mode, you normally only need one external pushbutton (MSG1), because the HK828 records and plays back either one message or a sequence of messages, using all of its memory space.

That's it then – an easy-to-build solid-state Multi-Message Voice Recorder module that can be used for all kinds of applications, especially those involving sending pre-recorded messages over an amplifier or PA system under the control of a PC or microcontroller. *EPE*

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Decoding The Heavens

TechnoTalk

Mark Nelson

This month we're looking skywards for inspiration, triggered by the Planet Jupiter radio receiver featured in last September's issue. Mark would like to dig deeper into radio astronomy (and radio astrology!) and explain the fascination of this activity, and the role electronic hobbyists can play in this area. Another allure covered this time is the music of the magnetosphere that is inaudible to most people.

THE easy-to-build *Planet Jupiter Receiver* (Sept '10) must have surprised many readers by how easily (and cheaply) a normal professional electronicist can get into a study area that most people consider the preserve of practised scientists. But as the article explained, you don't need a PhD to carry out 'real' radio astronomy, nor do you have to build a steerable dish the size of Jodrell Bank in your back garden. You don't even need a lab full of fancy equipment either, a PC and modified shortwave receiver (and wire dipole antenna) is all you need to start.

Is the bug biting?

If you're tempted by listening to the sky and would like to read more, there's plenty on the WWW. Take a look at the UK Amateur Radio Astronomy website at: **www.ukaranet.org.uk/** and NASA's *Basics of Radio Astronomy* guide at: **www2.jpl.nasa.gov/radioastronomy**. There's also a Society of Amateur Radio Astronomers (**www.radio-astronomy.org**) and well, I'll let you Google for more.

You can find useful help in books too. The RSGB (Britain's 'ham' radio organisation) publishes a very comprehensive tome called *Amateur Radio Astronomy;* it has no equivalent elsewhere. Full of practical projects, it also explains how hobbyists have contributed to the science of radio astronomy (get it direct from: **www.rsgbshop.org**).

Another book that I would recommend for its enthusiasm and straightforward explanation is Frank Hyde's *Radio Astronomy For Amateurs*. Although it was published nearly 40 years ago, and the circuits are nearly all valve-based, the theory is still entirely valid. Try asking your local library to obtain it for you through inter-library loan or else you may be lucky enough to find it second-hand at a realistic price (the book is highly sought after now).

Radio astrology too?

I don't know about you, but it always amuses me the way my local branch of WHSmith places astrology magazines next to *Astronomy Now*, *Sky At Night* and *Sky & Telescope*. This must really annoy the 'serious' astronomers. But I thought I'd do a quick Google to see if anyone was using radio to work out astral predictions. Reassuringly, there is a website: ***www.radioastrology.com***, but my satisfaction was tempered somewhat when I discovered it's an Internet radio site streaming out information on astrology, metaphysics, psychic and spiritual awareness, as well as expanding your consciousness. Mind you, that's plenty to be getting on with.

Digging deeper, I did find a report from last year in the *Pretoria News* of South Africa that states 'Africa and Australia are the final two countries still bidding to host Square Kilometre Array (SKA), the most powerful radio astrology telescope on Earth'. My only disillusion is the date of the article, which is 1 April 2010.

Still in mystical mood, back in ancient times some people imagined that the movements of celestial bodies (the sun, moon and planets) had, a form of music known as the 'music of the spheres'. This music was not usually thought to be audible in a literal sense, but as a harmonic and/or mathematical and/or religious concept. The notion can apparently be traced back to Jewish beliefs about an orderly cosmos hymning the praises of its creator and continued to influence thinkers until the end of the Renaissance period.

Music of the magnetosphere

A more up-to-date kind of heavenly melody is the 'broadcast' music of the northern lights. Part of the wider phenomenon of 'natural radio', it is transmitted on the very low-frequency or VLF bands. These signals are in the audio frequency and occur from approximately 200Hz to beyond 10kHz. They are not man-made but occur naturally in nature, the most spectacular ones being heard between 400Hz and 5kHz.

This is a natural (sorry!) field for electronics experimenters, and in a moment I'll give you some websites where you can find practical information. As one enthusiast extols, the sheer enjoyment of listening to yet another realm of nature's beauty means many people who are not really 'radio nuts' or 'techies', but who love nature and listening to interesting sounds, have listened to natural radio either live or recorded and have called it the 'music of Earth itself'.

So what is the source of these noises? Lightning storms, the Earth's magnetic field itself and the *aurora borealis* and *australis* (northern and southern lights) all produce an amazing variety of electromagnetic sounds. For example, 'sferics' (static from lightning strokes), tweeks, 'whistlers', the incredible 'chorus' of chirping, barking and squawking produced by the Sun's solar wind colliding with the Earth's magnetic field; various kinds of hiss, 'wavering tone' emissions and other fascinating sounds to hear.

Curious chorus

Some of these sounds are plain bizarre, but the ones termed 'chorus' are genuinely musical, sounding like the most fantastic ever dawn chorus of birds twittering and chirping. Some of these have been released on CD in the past (I bought an album at the HMV store in London's Oxford Street), but nowadays you can get them straight off the Internet. National Public Radio in the USA broadcasts a fascinating documentary called *Listening to the Northern Lights*, which you can hear or download.

Interestingly, these noises are not a space age discovery—far from it in fact. They were first heard on long telephone wires in the 1880s, and VLF enthusiast Stephen McGreevy argues that these mysterious radio signals of Earth were the first radio signals that people ever heard.

He's probably right if you accept that frequencies in the audio range are in fact radio. Certainly you cannot hear them through your ears unless you were one of those telephone operators in the late 19th century in Britain and the USA who heard strange whistling tones in the background of long-distance telephone calls.

At the time, these noises were attributed to problems in the wires and connections of the telephone system and disregarded. A paper of 1894 by W H Preece, engineer-in-chief of the British Post Office, appearing in *Nature* magazine describes operators at the British Government Post Office who listened to telephone receivers connected to telegraph wires and heard the 'bubbling and murmuring' sounds of the *aurora borealis*.

Today's experimenters use receivers that can be very simple or quite sophisticated, with either a whip antenna or crossed multi-turn loops. The best recordings are made in electrically quiet locations, far away from AC power lines, and the real enthusiasts make elaborate expeditions, camping out in US deserts, the remote northern lakes of Canada, woodlands in Ireland or deep in Battersea Park, London.

Recommended websites

www.auroralchorus.com/natradio.htm
Exuberant general introduction

www.auroralchorus.com/vlfstory.htm
Recording expedition

www.vlf.it/kurt/elf.html DIY receiver project

www.auroralchorus.com/bbb4rx3.htm
Simple receiver project

www.auroralchorus.com/wr3gde.htm
Receiver listening guide

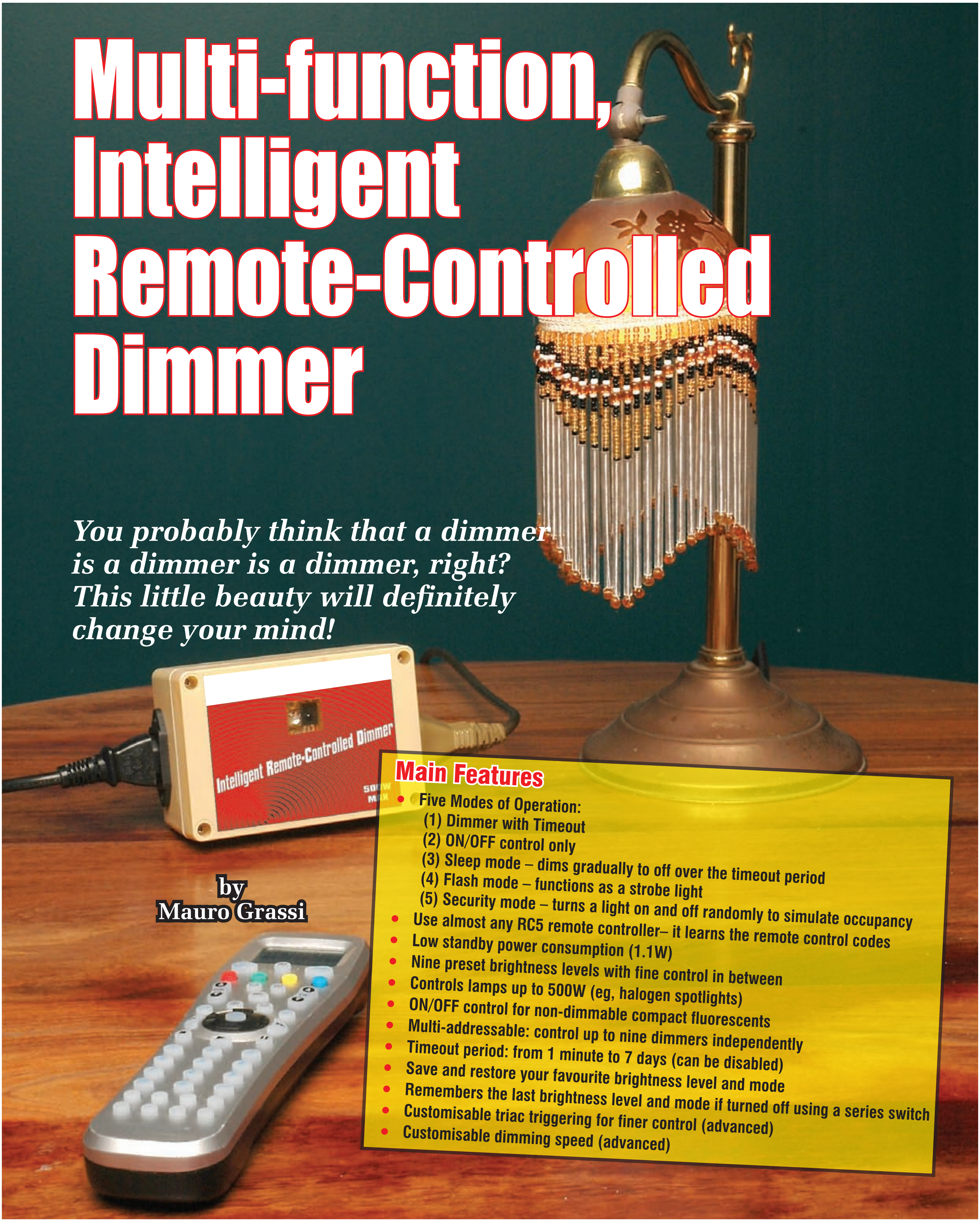
www.auroralchorus.com/vlfquiet.htm
Quiet recording locations

www-pw.physics.uiowa.edu/mcgreevy/
Recordings in MP3 format

www.npr.org/programs/lnfsound/stories/990326.stories.html
Listening to the Northern Lights (radio programme)

www.auroralchorus.com/vlfstory.htm
The history of VLF reception

Multi-function, Intelligent Remote-Controlled Dimmer

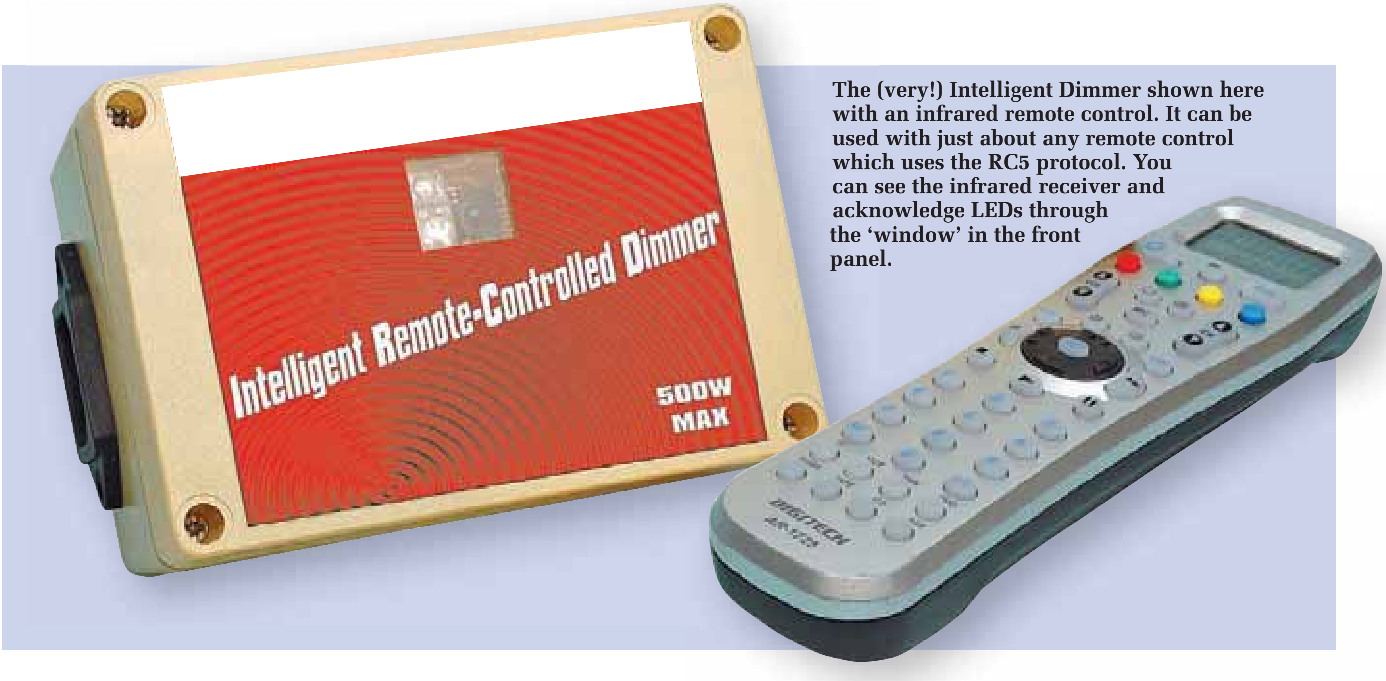


You probably think that a dimmer is a dimmer is a dimmer, right? This little beauty will definitely change your mind!

by
Mauro Grassi

Main Features

- Five Modes of Operation:
  - (1) Dimmer with Timeout
  - (2) ON/OFF control only
  - (3) Sleep mode – dims gradually to off over the timeout period
  - (4) Flash mode – functions as a strobe light
  - (5) Security mode – turns a light on and off randomly to simulate occupancy
- Use almost any RC5 remote controller– it learns the remote control codes
- Low standby power consumption (1.1W)
- Nine preset brightness levels with fine control in between
- Controls lamps up to 500W (eg, halogen spotlights)
- ON/OFF control for non-dimmable compact fluorescents
- Multi-addressable: control up to nine dimmers independently
- Timeout period: from 1 minute to 7 days (can be disabled)
- Save and restore your favourite brightness level and mode
- Remembers the last brightness level and mode if turned off using a series switch
- Customisable triac triggering for finer control (advanced)
- Customisable dimming speed (advanced)



The (very!) Intelligent Dimmer shown here with an infrared remote control. It can be used with just about any remote control which uses the RC5 protocol. You can see the infrared receiver and acknowledge LEDs through the 'window' in the front panel.

THIS remote controlled dimmer will work with incandescent and dimmable CFL (compact fluorescent) lights, as well as some 12V halogen lights. It can provide mood and home-theatre lighting or operate in SLEEP mode (eg, in an infant's room) to very gradually fade a lamp.

This dimmer also has 'intelligence' – it can automatically turn off the light after a timeout period ranging from one minute to almost a week, ensuring the light is not left on if you forget to switch it off. It can also be used to control non-dimmable CFLs. In this mode, we simply turn the CFL ON and OFF (note: it may *NOT* be suitable with some non-dimmable CFLs, which tend to flicker in the 'OFF' state).

Want to individually dim more than one table lamp in a room? No problem; you could have up to nine of these dimmers in a room, independently controllable with the same remote. In addition, you can also control two or more dimmers simultaneously!

You can use almost any RC5 remote control, because the light dimmer can be programmed to learn the command codes. Pretty neat, eh? You use the number keys to dim to a preset level, or the VOL UP and VOL DOWN keys to dim up or down in fine increments. Button '0' dims down to off, while '9' dims up to fully on.

In addition, we have attempted to provide just about every possible remote control feature in this design. It is quite a simple circuit, but the microcontroller's program provides all these features.

Circuit description

The circuit (Fig.1) is based around a PIC18F1320 microcontroller, which controls the triac and responds to all the remote control commands. In addition, there is the infrared decoder IDR1, two RGB LEDs, an *NPN* transistor, two diodes, a Zener diode, a 10MHz crystal and an inductor and a few resistors and capacitors.

The triac is connected between the mains live and the lamp via inductor L1. In conjunction with a 100nF 250V AC capacitor, this inductor provides suppression of electromagnetic interference caused by the rapid switching of the triac.

The micro sends gate pulses to the triac via NPN transistor Q1 and ultra-fast recovery diode D2. This diode protects the transistor from spikes generated when the triac changes state from conducting to non-conducting and *vice versa*.

The micro controls the power level fed to the lamps by the triac by varying the timing of the gate pulse during each half-cycle of the 230V AC mains waveform.

If the gate pulse is early in each half cycle, the power level will be high (ie, the lamp will be bright). Conversely, if the gate pulse comes late in each half cycle, the power level will be low (ie, the lamp will be dim). This method of power control is referred to as 'phase control'.

In order to know when in each half cycle to issue the gate trigger pulse, the microcontroller must be properly synchronised to the mains waveform at 50Hz. This is accomplished by a sync pulse taken directly from the neutral mains connection via a 3.3MΩ 1W resistor. The sync signal is filtered by a 4.7nF capacitor, which forms a low-pass filter with the 3.3MΩ resistor, and synchronisation occurs every half cycle of the mains waveform, at a 100Hz rate.

WARNING!

This circuit is directly connected to the 230V AC mains. As such, all parts operate at mains potential (ie, at 230V AC) and contact with any part of the circuit could be FATAL. This includes both sides of the PC board.

DO NOT connect this device to the mains unless it is fully enclosed in the specified plastic case. DO NOT remove the lid of the case or touch any part of the circuit unless the power cord is unplugged from the mains socket.

This project is NOT for the inexperienced. DO NOT attempt to build it unless you know exactly what you are doing and are completely familiar with mains wiring practices and construction techniques.

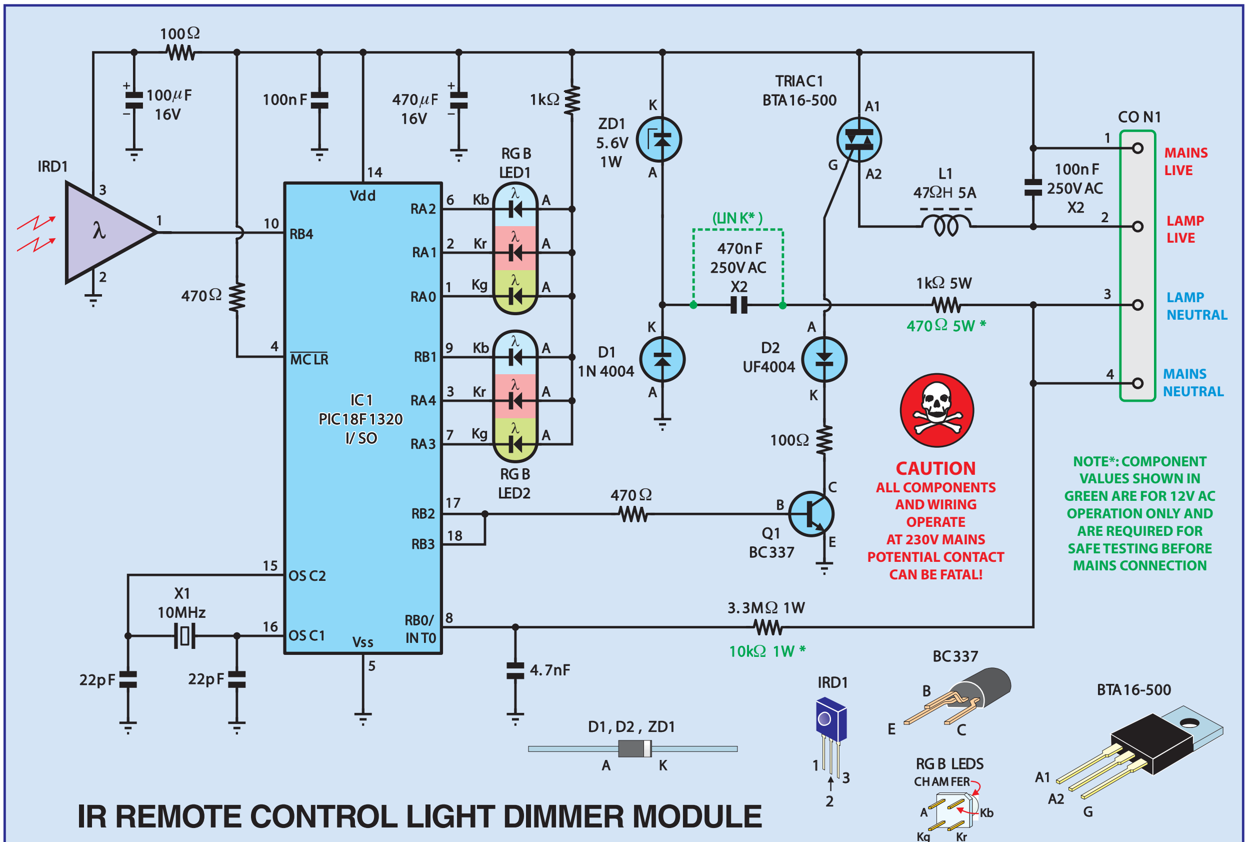


Fig.1: the circuit is based on a PIC18F1320-I/SO microcontroller, a triac and an IR detector (IRD1). The two RGB LEDs give user feedback on the operation and settings.

Power supply

You may wonder how the micro can be synchronised to the mains waveform by connecting it to the neutral side of the mains supply. Isn't this the low-voltage side of things?

Yes it is, but the microcontroller is actually tied to the live side of the mains supply. Power for the micro is derived from the mains via a 1kΩ 5W resistor and a 470nF (X2) capacitor. The capacitor and resistor act as a current limiting impedance for the associated 5.6V Zener diode, ZD1.

The supply circuit works as follows. First, for positive half cycles of the 230V AC, current flows via ZD1, the 470nF capacitor and 1kΩ 5W resistor. At the same time, the 470µF 16V electrolytic capacitor is charged up. Then, for negative half cycles of the mains, current flows via D1, the 470nF capacitor and the 1kΩ resistor. The result is that the 470µF capacitor is charged to 5.6V – 0.6V = 5V DC.

The impedance of the 470nF capacitor at 50Hz is 6.77kΩ, and in series with the 1kΩ resistor, this gives a total impedance of 6.84kΩ. Hence, the 5V supply can deliver up to 23mA. Apart from the current drain of the micro itself and IRD1, the circuit must supply the gate power to the triac and drive the two RGB LEDs. These LEDs are connected with each of the six cathodes connected to a different I/O pin of the micro, IC1.

The common anodes of the two RGB LEDs are connected together and to the 5V rail via a single 1kΩ current-limiting resistor. For this reason, only one LED (there are three within each RGB LED) is ever lit at any one time.

The LEDs are lit to acknowledge key presses, to prompt the user for input and to give feedback on current settings. We explain the user operation in detail later.

Signals from the IR remote control are amplified, filtered and decoded by the receiver module (IRD1). The 100Ω resistor and 100µF capacitor are used to decouple its 5V supply. The data output at pin 1 of IRD1 is connected to pin 10 of IC1, and configured as a digital input.

Construction

The Intelligent Dimmer is built on a single-sided PC board, code 799, measuring 76mm × 50mm. It is housed in a sturdy

Programming the PIC Micro

If you purchase this project as a kit, the PIC microcontroller will be pre-programmed. If not, you will need to program the PIC with the Dimmer software, downloadable from the *EPE* website at **www.epemag.com**, before soldering it to the PC board.

To do this, refer to the 'PIC Programmer SOIC Converter', published in the September 2009 issue (page 30) of *EPE*. That simple project will allow you to interface the SMD PIC to a common PIC programmer with a ZIF socket. The PC board for this adaptor is available from the *EPE PCB Service*, code 723.

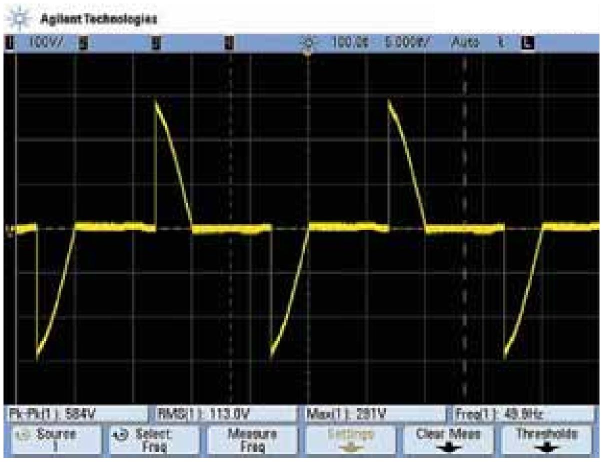


Fig.2: this oscilloscope screen grab shows an incandescent lamp being switched using phase control. The yellow trace shows the waveform at the A2 terminal of the triac.

polycarbonate case (125mm × 85mm × 55mm) with a clear lid and neoprene lid-sealing gasket. The circuit board is available from the *EPE PCB Service*.

The component overlay diagrams for both sides of the PC board are shown in Fig.3. **Note that the circuit diagram and Fig.3 both show three components which must initially be installed to allow the dimmer to operate at 12V AC. This enables you to check its operation at a safe low voltage before changing these parts to allow it to operate at 230V AC.**

To build the 12V AC version, you simply install a wire link in place of the 470nF 250V AC capacitor, a 470Ω 5W resistor instead of the 1kΩ 5W unit and a 10kΩ 1W resistor instead of the 3.3MΩ 1W unit.

Check the PC board for any defects before starting the assembly. That done, the next job is to install the programmed PIC microcontroller on the *copper* side of the board. Note that the microcontroller is an SMD, and must be the 18F1320-I/SO (in the SOIC 18-pin package). Make sure it is oriented correctly.

You will need a fine-tipped soldering iron to do the job. Position the IC over the pads and solder pin 17 and pin 18 first. Then solder pin 9, followed by the remaining pins. Be careful not to get solder bridges between adjacent pins.

Once the micro is in, flip the board over and install the parts on the component (top) side. Start by installing the four wire links, plus the link in place of the 470nF 250V AC capacitor. Follow these with the seven resistors. Start with the smallest and leave the 470Ω 5W wirewound resistor until last.

Install the diodes next; be sure to get their orientation correct. Zener diode (ZD1) and the 1N4004 (D1) go in the top right-hand corner, while the UF4004 (D2) goes near the triac.

Now solder in the BC337 *NPN* transistor (Q1). It can only go in one way. That done, bend the leads of the triac down by 90° about 9mm from its body, then install it so that it sits horizontally on the PC board (metal tab down), as shown in Fig.3 and the photos. **Do not substitute for the triac – check its part number carefully.**

The capacitors can now go in. The two larger electrolytic capacitors must be oriented correctly.

The 47µH inductor is next on the list – it sits vertically on the PC board. Make sure that the enamel coating on the leads is stripped away on the tips prior to soldering. Follow with the 4-way socket (CON1) and the 10MHz crystal.

Parts List – Intelligent Dimmer

1 PC board, code 799, available from the *EPE PCB Service*, size 76mm × 50mm
1 IP65 sealed ABS plastic case with clear lid, size 125mm × 85mm × 55mm (Jaycar HB-6246)
1 flush-mount 3-pin mains socket (Jaycar PS-4094) or similar
1 IEC male chassis connector with mounting holes (Jaycar PP-4005)
1 10MHz crystal (X1)
1 47µH 5A inductor (Jaycar LF-1274)
1 4-way 'Dinkle' vertical socket (CON1) (Jaycar HM-3114)
1 4-way 'Dinkle' screw terminal plug (Jaycar HM-3124)
1 10A IEC mains cord

Semiconductors
1 PIC18F1320-I/SO SOIC pre-programmed microcontroller (IC1)
1 IR receiver (Jaycar ZD-1952) (IRD1)
1 BTA16-500 *isolated tab* triac (TRIAC1) – DO NOT substitute
1 BC337 *NPN* transistor (Q1)
2 RGB 5mm common anode LEDs (LED1 and LED2)
1 1N4004 diode (D1)
1 UF4004 ultrafast diode (D2)
1 1N4734 1W 5.6V Zener diode (ZD1)

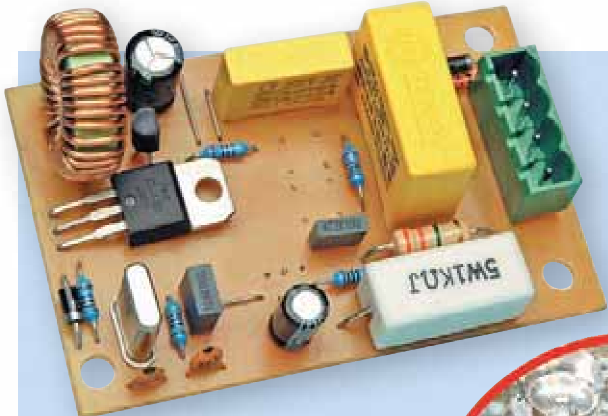
Capacitors
1 470µF 16V radial electrolytic
1 100µF 16V radial electrolytic
1 470nF (0.47µF) 250V AC X2 metallised polypropylene
1 100nF (0.1µF) 250V AC X2 metallised polypropylene
1 100nF MKT polyester
1 4.7nF MKT polyester
2 22pF ceramic

Resistors (0.25W, 1% unless specified)

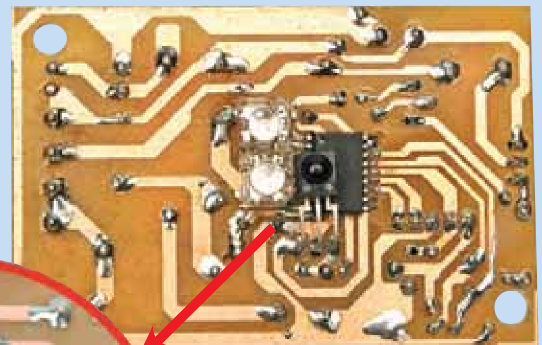
1 3.3MΩ 1W	2 470Ω
1 10kΩ 1W*	1 470Ω 5W wirewound*
1 1kΩ	2 100Ω
1 1kΩ 5W wirewound	* 12V operation only

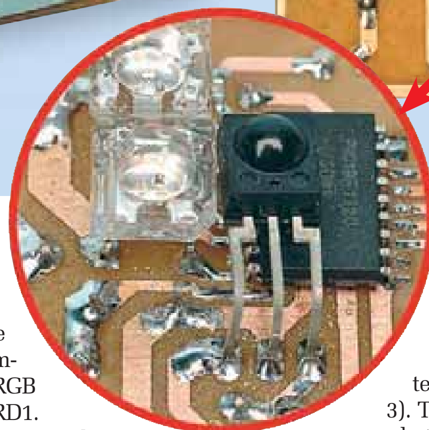
Miscellaneous
3 M3 × 25mm nylon screws (to secure PC board)
2 M3 × 15mm nylon screws (for IEC connector)
3 M3 × 12mm nylon spacers
10 M3 nylon nuts
1 100mm of 0.7mm-dia. tinned copper wire (for links)
1 200mm length 3-core mains flex (250V 10A rating)
1 4.8mm red spade connector, fully insulated
1 4.8mm blue spade connector, fully insulated
1 4.8mm yellow spade connector, fully insulated
5 100mm cable ties

Additional Parts Required For testing
1 12V AC 500mA or 1A plugpack
1 12V 300mA light bulb (Jaycar SL-2656)



The 'normal' component side of the PC board carries most of the components ...





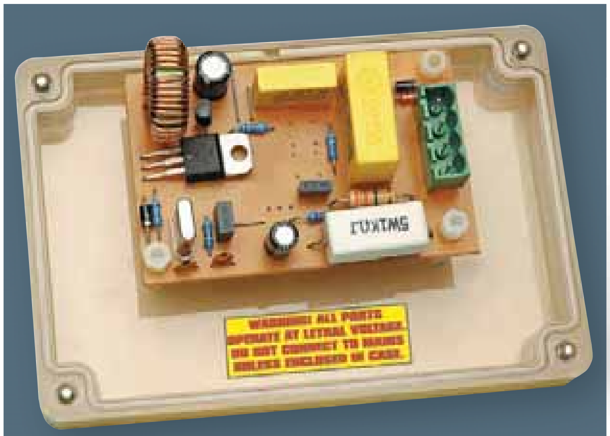
... however, there are four parts, including the PIC, mounted on the copper side (see enlargement at left).

Note particularly the orientation of CON1 – it must be installed exactly as shown, with its grooved side towards the right-hand edge of the PC board.

Now flip the PC board back over to the copper side again. There are three more components to be fitted to this side: the two RGB LEDs and the infrared receiver module IRD1.

Start with the two RGB LEDs. These go in with a very specific orientation, so refer to the component overlay before proceeding. Be careful not to use too much heat when you solder in the LEDs, because excessive heat can easily destroy them (or the fine connecting leads inside the RGB LED). We recommend using a temperature-controlled soldering station, set to no more than around 300°C. The RGB LEDs sit about 5mm from the PC board, and you will need to also be careful that you don't melt their plastic housing as you solder the leads to the copper side.

Finally, solder in the infrared receiver module (IRD1). Its mounted with its leads bent down by 90° about 10mm from its body. Make sure its domed lens faces upwards, as shown in the close-up photo.



Another view of the completed topside of the PC board, this time mounted on the case lid (note: mains version shown). Be sure to attach the warning label to the inside of the lid, as shown.

Testing on low voltage

Your dimmer is now ready for its *low-voltage* operation tests. First, connect a 12V 300mA light bulb (Jaycar SL-2656) between the LAMP LIVE and LAMP NEUTRAL connections on the 4-way screw terminal block CON1 (ie, between pins 2 and 3). That done, apply 12V AC from a plugpack supply to pins 1 and 4 of CON1. You can then use your remote control to run through the various dimmer modes and functions (see features panel).

Note that the low voltage version may show signs of flickering at high-brightness settings, because the synchronisation with the zero crossings of the mains will be offset by the AC plugpack. This problem should not occur with mains operation.

Converting to mains operation

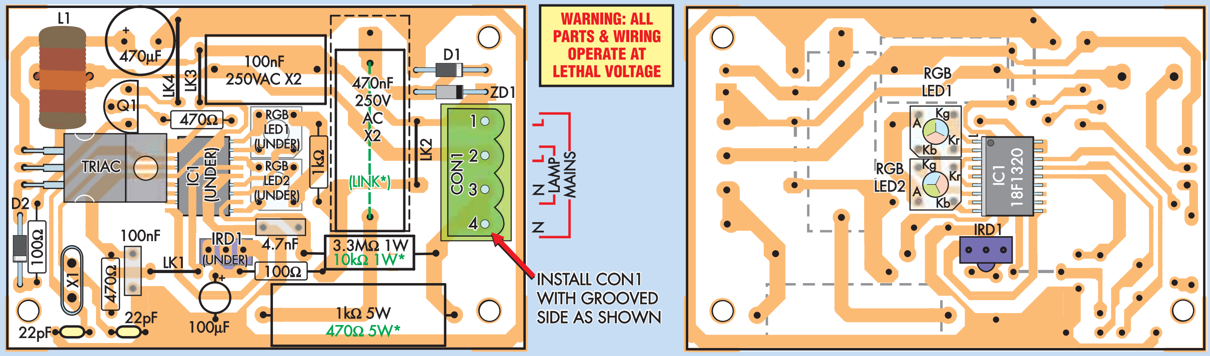
Having successfully tested the circuit with a 12V AC plugpack and light bulb, you can now disconnect power and install the three components for mains operation: the 470nF 250V AC X2 capacitor (ie, remove the link), the 3.3MΩ 1W resistor and the 1kΩ 5W resistor.

Having done that, the case can be prepared to accept the hardware. We used an IP65 sealed ABS case with clear lid, and with dimensions of 125mm × 85mm × 55mm.

You will need to make two cutouts in the sides to fit the male chassis-mount IEC socket and the 3-pin mains outlet socket (GPO). The template is shown in Fig.4. The IEC socket is attached using two nylon M3 × 12mm screws and four nuts. The second nut at each location locks the first in place, to ensure that the IEC socket cannot possibly come loose.

Important: do NOT use metal screws to secure the IEC socket (or PC board). All the circuitry inside the case will be at 230V AC potential, so we do not want any exposed metalwork on the case, therefore nylon screws must be used. For the same reason, you must house this project in the specified plastic case. DO NOT use a metal case.

You now need to make the internal connections between the IEC input socket, the 4-way 'Dinkle' plug connector for the PC board and the 3-pin GPO socket. Use 250V AC 3-core flex for this job. Strip the outer sheath to reveal the three coloured wires – brown is for live, blue is for the neutral and green/yellow is for the earth connection. **Be sure to wire the Dinkle connector plug exactly as shown in Fig.6 and the photo below it.**



COMPONENT SIDE OF BOARD — THE THREE COMPONENT VALUES IN GREEN & MARKED WITH AN ASTERISK (*) ARE INSTALLED FOR 12V AC OPERATION *ONLY* — COPPER SIDE OF BOARD

Note: components marked in green must be installed first to build the low-voltage (12V AC) version for testing (see text). After testing, these parts are removed and the alternate parts installed for mains operation.

Fig.3: the component overlay for both sides of the PC board. Remember that the low-voltage version (green components) MUST be built first and the module then tested using a 12V AC plugpack. Only if the low-voltage version passes testing should you proceed to install the three components needed for mains operation (marked with an asterisk – see text).

A ratchet-driven crimping tool is needed to crimp the ends of the three wires connecting to the male IEC socket with the 4.8mm spade lugs. Don't rely on squeezing with plier-type (automotive) crimpers, as these will not give safe, reliable connections. The connections are shown in Fig.6.

If you are unable to obtain fully-insulated 4.8mm connectors, then use non-insulated connectors, but be sure to **fully insulate** them using 6mm-diameter heatshrink tubing after the leads have been crimped – see photo.

Use cable ties to secure the mains wiring, as shown in Fig.6 and the photos. Note particularly how the live, neutral and earth leads are connected to the mains outlet socket and secured using cable ties. The terminals are marked 'L' (for live), 'N' for neutral and 'E' for earth. Check that each mains wire is run to its correct terminal on both the outlet socket and the IEC input connector.

Drilling the lid

The next step is to drill the mounting holes in the lid for the PC board. Fig.8 shows the mounting hole locations and can be used as a drilling template. The front-panel label (Fig.9) can then be attached. Cover the label with clear film and cut out the window before fitting it. It can be affixed to the lid using a thin smear of neutral-cure silicone sealant as the adhesive. Finally, cut out the three PC board mounting holes using a sharp knife.

To improve the presentation in the magazine, we sprayed the outside of the case with a cream gloss plastic paint, but this step is unnecessary for the home constructor. This was

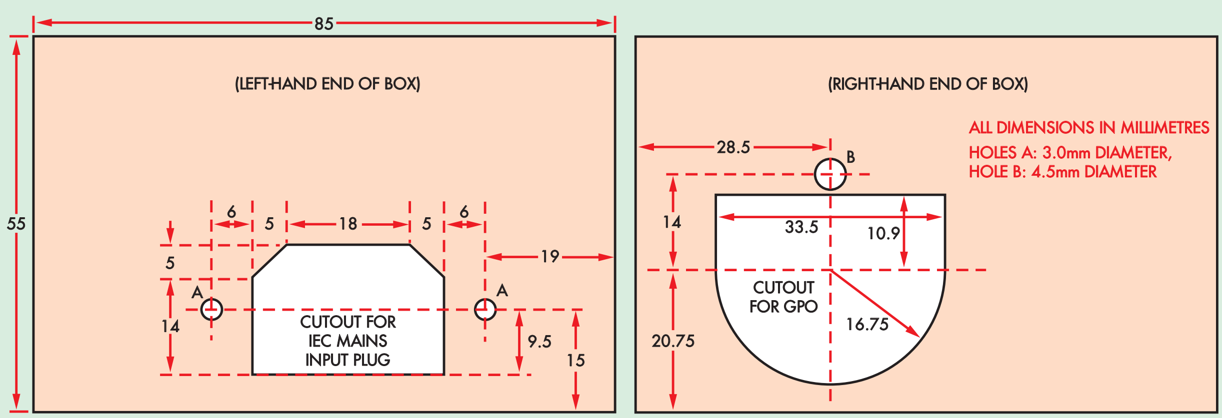


Fig.4 (above): the cutouts you will need to make in the case to accommodate the IEC mains input connector and the 230V mains outlet on the opposite end. The mains output soket (GPO) cutout will, of course, depend on the type used.

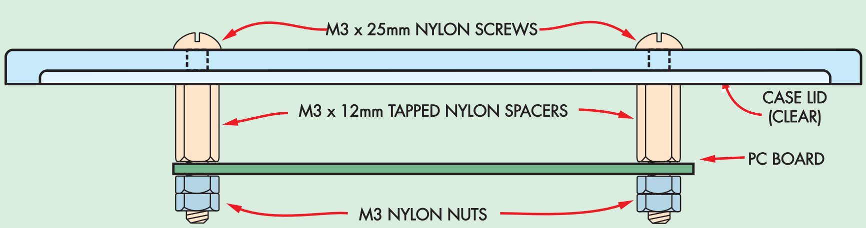


Fig.5 (left) shows how the PC board 'hangs' from the case lid on M3 × 12mm tapped nylon spacers. Be sure to use nylon screws and nuts to secure the assembly

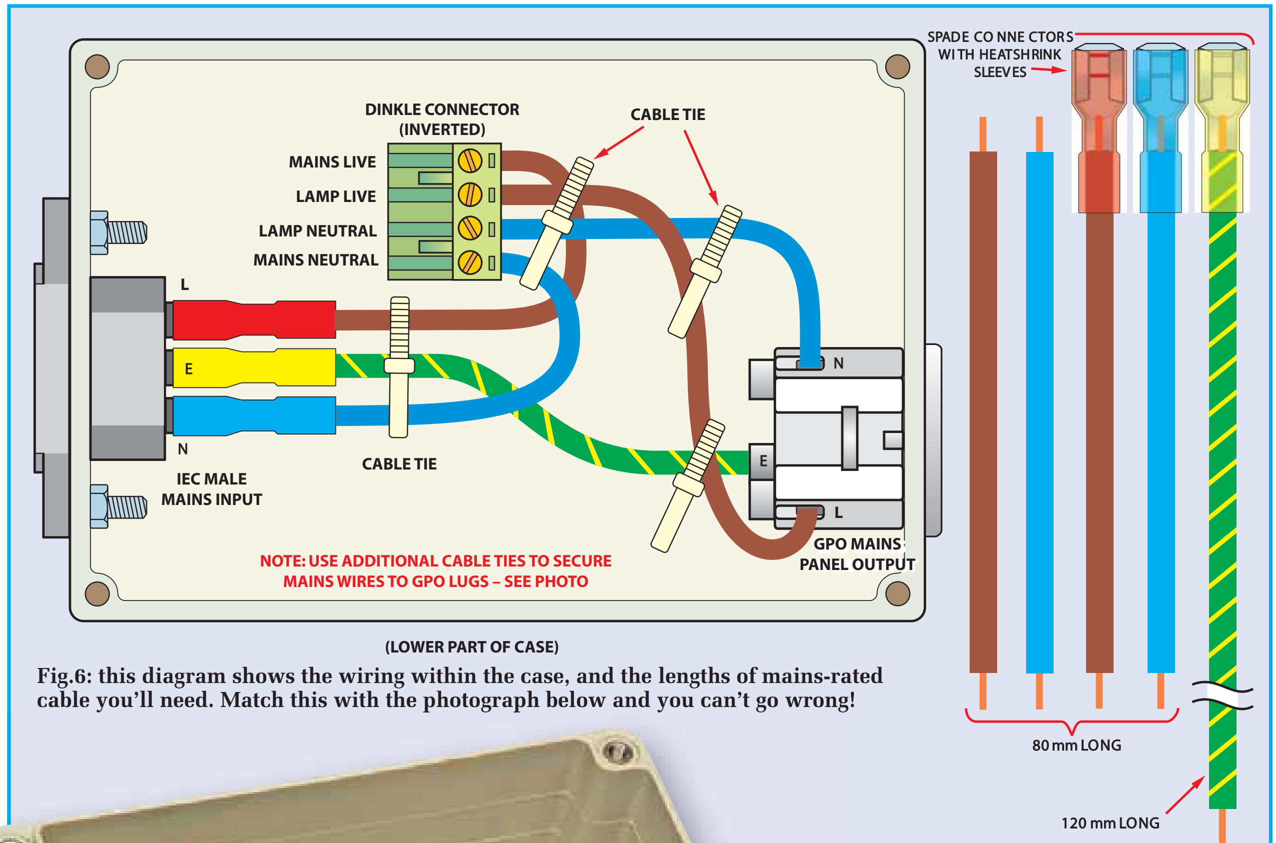
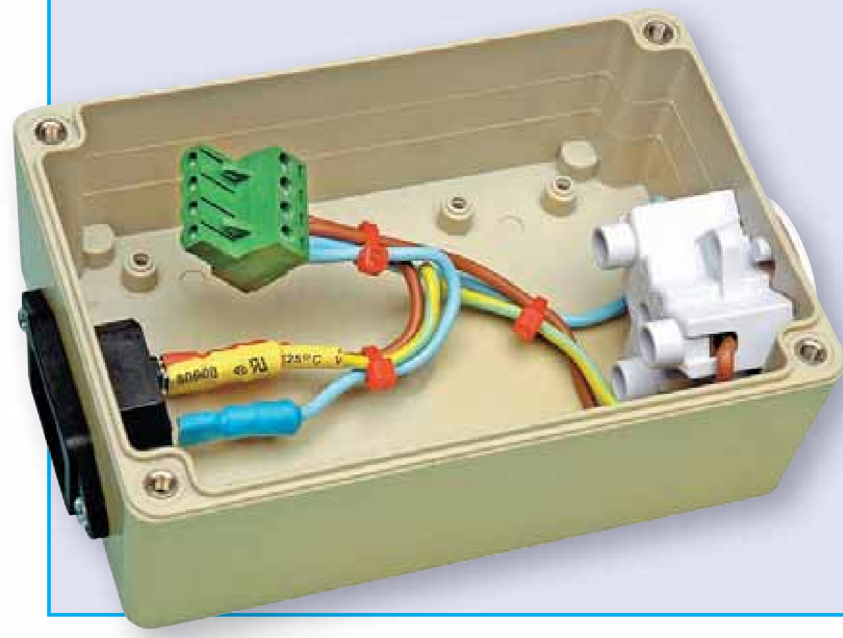
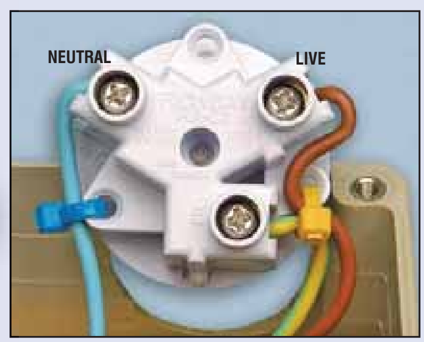


Fig.6: this diagram shows the wiring within the case, and the lengths of mains-rated cable you'll need. Match this with the photograph below and you can't go wrong!





This close-up view shows how the GPO outlet socket is wired. Note how the wires are secured to the socket using cable ties.

done before the label was attached and after first removing the wiring and the two sockets and masking off the holes so that no paint could get inside. The lid was left on, but the top recess was masked off to leave a clear window for the LEDs and IR receiver. If you do paint the case, use plastic paint and ensure that no paint gets inside; it could compromise its insulation properties.

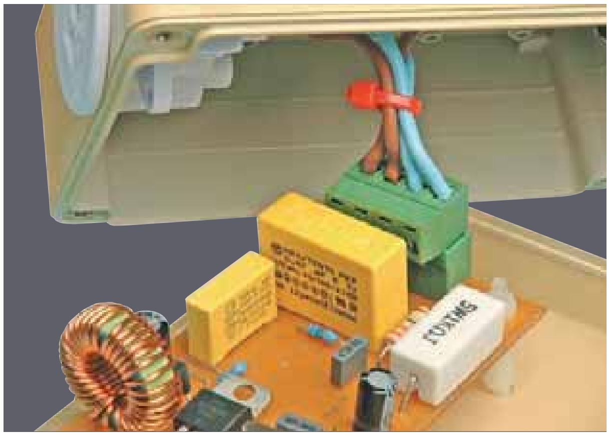
Mounting the PC board

The PC board is mounted on the clear lid of the case using three M3 × 25mm nylon screws, three M3 × 12mm nylon spacers and six nuts – see Fig.5. **Note again that you must use nylon (NOT metal) screws and standoffs to ensure safety.**

Once the board has been mounted, the Dinkle connector can be plugged into CON1. **As shown in one of the photos, it should go in with its screw terminals towards the 470nF 250V AC capacitor, and with the 'mains live' wire adjacent to Zener diode ZD1. Check this carefully, then attach the lid to the case.**

WARNING! ALL PARTS OPERATE AT LETHAL VOLTAGE. DO NOT CONNECT TO MAINS UNLESS ENCLOSED IN CASE.

Fig.7: this warning label should be affixed inside the case, eg, to the lid.

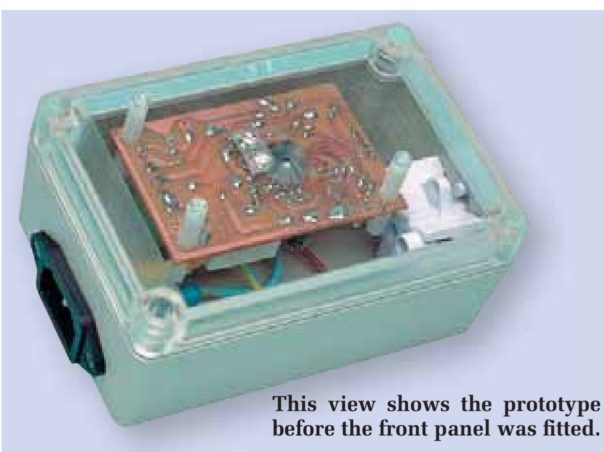


The Dinkle connector is plugged into CON1, as shown here. Make sure that its mains live lead is adjacent to Zener diode ZD1 on the PC board, with the neutral wires towards the 1kΩ 5W resistor.

Getting it going

The next step is to use your multimeter (set to a low ohms range) to check between the earth pin of the IEC connector and the earth pin of the flush-mounting mains output socket. You should get a reading of zero ohms here (this checks the integrity of the earth connection).

Before applying power, refer to the warning panel earlier in the article. All the circuitry operates at 230V AC and you must NOT connect this device to a mains wall socket unless it is fully enclosed in its plastic case (ie, with the lid on). If it's plugged in, the circuit could still be live, even if the mains switch is off at the wall – ie, if live and neutral have been transposed at the wall socket. You have been warned!



This view shows the prototype before the front panel was fitted.

Important Points To Check

(1) Be sure to use the specified ABS plastic case and note that nylon screws *must* be used to secure the IEC connector and to secure the PC board to the lid (via tapped nylon spacers).

(2) Use mains-rated cable for all connections to the IEC mains socket and to the flush-mount 3-pin mains outlet socket. Secure these leads with cable ties, as shown in Fig.6 and the photos.

(3) Use fully-insulated spade connectors to terminate the leads to the IEC connector. A ratchet-driven crimping tool is necessary to fit these spade connectors and ensure safe, reliable connections.

Provided the lid is fastened down, you can now plug in a lamp and apply mains power to the unit via the IEC socket. If you are using a Digitech remote control from Jaycar (Cat. AR-1726), just set it to VCR code 917 and it should just work. Check the panel on the following four pages for information on using other remote controls.

Reducing standby power

Although the standby power is relatively low at about 1W, you may wish to eliminate this by switching power off altogether when the dimmer is not in use. The best way to do this is with an in-line switch in the mains cord to the IEC socket.

When you turn power off using the switch, the brightness setting level will be restored when you apply power next time.

OVERLEAF: Dimmer features – and how to use them!

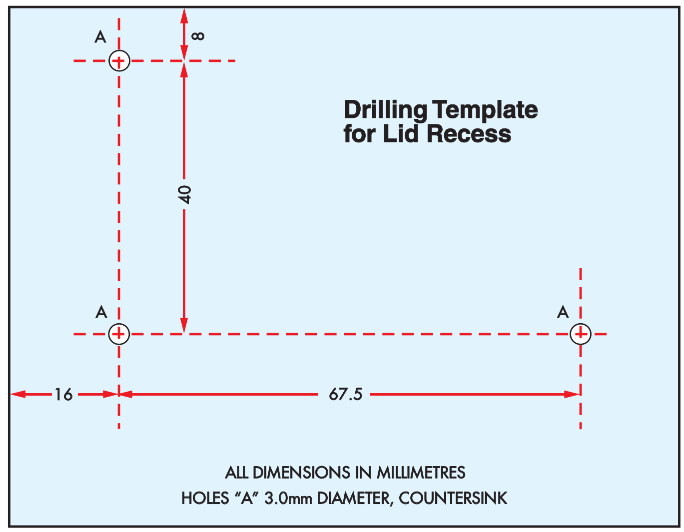


Fig.8: use this diagram as a drilling template for the case lid (it fits in the recess in the top of the lid).

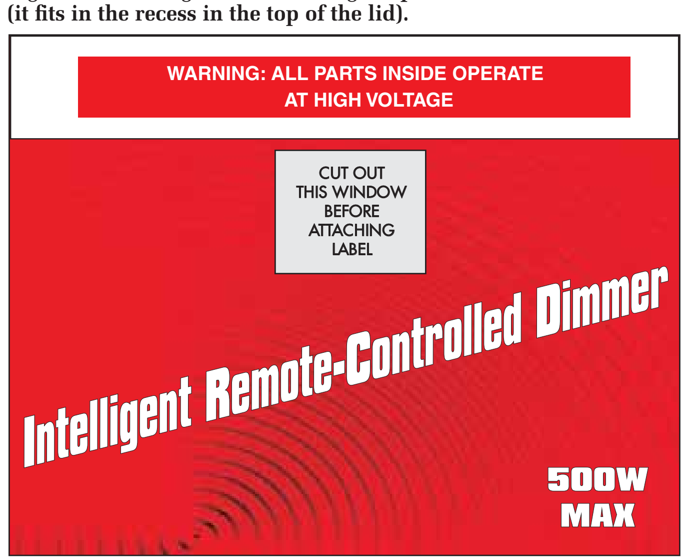


Fig.9: this full-size artwork for the front panel can be photocopied and glued to the lid.

Dimmer features – and how to use them!

The remote control

We tested the Intelligent Light Dimmer with a range of universal infrared remote controls, including the Digitech AR-1726 (Jaycar Cat. AR-1726). Set the Digitech remote control to the VCR-917 code (this is the code for a Philips VCR). This is the default (pre-programmed) code in the PIC micro (IC1), so if you use the Digitech remote, you don't have to do anything else!

However, the dimmer can be operated using any RC5 remote control, because the control codes can be 'learnt'. There are 20 codes that the light dimmer recognises and these are listed in Table 1, together with their function.

If the light dimmer senses infrared activity, but it is not one of the 20 codes recognised, it will be ignored. However, if the same unrecognised code is pressed 10 times consecutively, the light dimmer will enter the remote control programming menu that lets you define the remote control codes for each of the 20 functions.

Once this menu is entered (you will see the LEDs flash to indicate that the menu is being entered). You will then be prompted, by flashing LED codes, to define each of the 20 remote control codes used to operate the light dimmer. The LED codes for each command are shown in the LED Code column in Table 1.

So, for example, when you see the LED code for '1' (a single flash from the top green LED), you should press the key on your RC5 remote that you want to define for the function that '1' has (in this case, it functions both to enter settings and to set the brightness to 11% of full brightness).

After all 20 remote control codes have been successfully defined, they will be stored in EEPROM, so this only needs to be done once.

User operation

As noted above, up to 20 keys can be programmed with separate functions. For example, the number keys are used to dim to preset levels, while the VOL UP and DOWN buttons can dim up and down in fine increments. The Channel UP and DOWN keys are used to change the operating mode (five modes), the MENU button lets you enter one of the 10 menus and the INFO button lets you see the current settings and

Button Name	Function(s)	LED Code	Recommended Key Definitions for the Digitech AR-1726 remote (defaults)
OK/ADDRESS	In normal operation, this button is used to set the address (OK/ADDRESS + number). If inside a menu, it can be used to exit the menu.	BBLUE x 2	Press 'OK'
TOGGLE	If light is on, dims it to off. If the light is off, dims it up to full brightness. If inside a menu, this is used to toggle the sign of the number being entered.	BBLUE x 1 + TBLUE x 2 (dimming up) or TBLUE x 1 + BBLUE x 2 (dimming down)	Press 'MUTE'
MODE UP	Go up to the next mode. The modes are, in order: Normal, ZV, Sleep, Flashing and Security.	BBLUE x 1 + TBLUE x 1	Press 'Channel Up'
MODE DOWN	Go down to the previous mode. The modes are, in order: Normal, ZV, Sleep, Flashing and Security.	TBLUE x 1 + BBLUE x 1	Press 'Channel Down'
INFO	In normal operation, this button is used to get information about the current settings. Press INFO + number to get the appropriate setting according to Table 3.	BGREEN x 1 + TBLUE x 1	Press 'STOP'
MENU	In normal operation, this button is used to enter a menu to change a setting. Press MENU + number to enter the appropriate menu according to Table 2.	BGREEN x 1 + TRED x 1	Press 'MENU'
UP	Dim up finely by 4%	BGREEN x 1	Press 'Volume Up'
DOWN	Dim down finely by 4%.	BRED x 1	Press 'Volume Down'
PLAY	Recall your favourite brightness level and operating mode (you must have previously saved those by using the RECORD button).	BGREEN x 2	Press 'Play'
RECORD	Press to save the current brightness and operating mode. You will then be able to recall these settings at any time by pressing PLAY.	BRED x 2	Press 'Record'
0	Dim to off.	TRED x 1	Press '0'
1	Dim to 11% of full brightness.	TGREEN x 1	Press '1'
2	Dim to 22% of full brightness.	TGREEN x 2	Press '2'
3	Dim to 33% of full brightness.	TGREEN x 3	Press '3'
4	Dim to 44% of full brightness.	TGREEN x 1 + BBLUE x 1	Press '4'
5	Dim to 55% of full brightness.	BBLUE x 1	Press '5'
6	Dim to 66% of full brightness.	BBLUE x 1 + TGREEN x 1	Press '6'
7	Dim to 77% of full brightness.	BBLUE x 1 + TGREEN x 2	Press '7'
8	Dim to 88% of full brightness.	BBLUE x 1 + TGREEN x 3	Press '8'
9	Dim to full brightness.	TGREEN x 1 + BBLUE x 2	Press '9'

Table 1: a suggested remote control code definition sequence using an RC5 remote control. This assumes you are using the Digitech AR-1726 universal remote control (although other universal remotes should be similar and may be used). Note that TGREEN denotes the top green LED, TRED the top red LED while BBLUE denotes the bottom blue LED, etc.

MENU Number	MENU Function
0	Reset and restore all default settings
1	Time Out Period (Minutes)
2	Flash Modulus
3	Quiescent Level
4	Address (0=Broadcast)
5	Limiting Phase 0 (Positive Half Cycle)
6	Limiting Phase 1 (Negative Half Cycle)
7	Offset Phase 0 (Positive Half Cycle)
8	Offset Phase 1 (Negative Half Cycle)
9	Dimming Delay

Table 2: the menu options. In each case, you press the MENU button followed by the appropriate number to choose that menu. Entering a menu is indicated by a specific sequence on the two RGB LEDs. You can then use other keys to set up the property (see text). In all cases, you press OK/ADDRESS to exit the menu.

INFO Number	INFO Function
0	Firmware Version (HLL=version H.LL)
1	Time Out Period (Minutes)
2	Flash Modulus
3	Mains Frequency (0.1 Hz)
4	Address (0=Broadcast)
5	Limiting Phase 0 (Positive Half Cycle)
6	Limiting Phase 1 (Negative Half Cycle)
7	Offset Phase 0 (Positive Half Cycle)
8	Offset Phase 1 (Negative Half Cycle)
9	Dimming Delay

Table 3: the information options. In each case, you press the INFO button followed by the appropriate number to choose that option. The information is then displayed using the two RGB LEDs, and can represent decimal numbers by different sequences of blinks (see text).

so on. Each time you press a recognised command, the two RGB LEDs will flash to acknowledge the command which will then be executed.

When a set dimming level has been reached, there will be an additional acknowledgment LED code of the operating mode.

So, for example, if you press '3', the LED code for '3' will be shown and then the dimmer will perform the command that it corresponds to. In this case, it will dim the light up or down in brightness so that it is at 33% of full brightness. When that level is reached, the light dimmer will issue the LED code for the current operating mode.

Number codes

The red blink indicates zero. One, two and three green blinks indicate, respectively, 1, 2, and 3. A blue blink indicates 5. Fig.10 shows all the number codes, along with the codes for plus and minus. Numbers like 128 or –2400 can also be shown. These multi-digit numbers have their digits codes shown in order from left to right.

When a number is displayed, the sign is displayed first. For example, the code to display 128 is (POSITIVE + 1 green blink + 2 green blinks + 1 blue blink + 3 green blinks). To display –2400 however, the code is (NEGATIVE + 2 green blinks + 1 green blink + 1 blue blink + 1 red blink + 1 red blink).

Once you use the light dimmer, you will quickly become used to the LED codes.

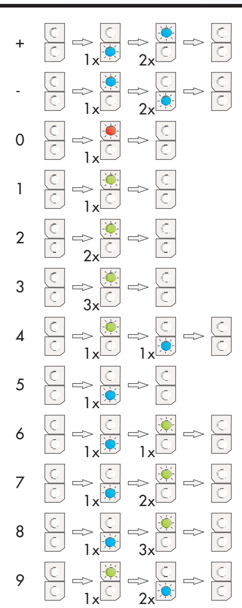


Fig.10: the LED acknowledge pattern codes for plus and minus, along with the numbers 0 to 9. These LEDs are clearly visible through the window in the front panel.

Operating modes

There are five operating modes. In order, they are: (1) Normal, (2) ZV, (3) Sleep, (4) Flashing and (5) Security. You use the Channel UP and Channel DOWN buttons to change the mode.

(1) Normal mode

Normal mode is the default. In this mode, the light can be dimmed over the full range. If the timeout is not disabled, the light automatically dims to off if no remote control activity has been detected for that period of time.

The dimming speed can be changed as well (see below). In this mode, you can dim the light up or down using the VOL UP and VOL DOWN and the number keys. You can also use the TOGGLE key to dim up to full brightness or dim down to off. Pressing any of the number buttons will dim the light to the preset level of that button. For example, pressing 4 will dim to about half brightness (actually 44%). Pressing 0 will dim to off and so on.

If you want to change the rate at which the lamp dims, you enter the menu mode, press the 9 button and then enter the dimming delay (0 to 9999) and press OK.

continued next page

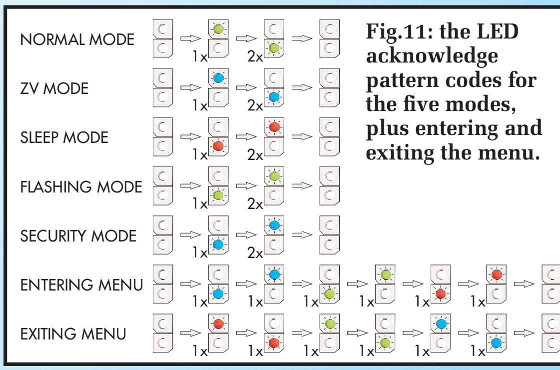


Fig.11: the LED acknowledge pattern codes for the five modes, plus entering and exiting the menu.

Timeout Period Digit Code (minutes)	Timeout Period	Power Consumption of a 100W light for the timeout period
30	Half an Hour	0.05 kWh
60	1 Hour	0.10 kWh
120	2 Hours	0.20 kWh
180	3 Hours	0.30 kWh
240	4 Hours	0.40 kWh
360	6 Hours	0.60 kWh
720	Half a Day	1.20 kWh
1440	A Day	2.40 kWh
9999	Almost a week	16.67kWh
0000	Disabled	–

Table 4: a selection of timeout period codes (in minutes) and what the timeout period will be. The 4-digit code in the left column must be entered when prompted in the timeout period menu to set the appropriate timeout period. To disable the timeout period function, enter a code of ‘0000’. To enable it, enter the appropriate number of minutes. The maximum timeout period is 9999 minutes, or almost a week. The longer the timeout period, the less chance that it will trigger when the light is in use, but the less power conservation protection offered.

(2) ZV mode

In ZV (zero voltage) mode, the light is only ON or OFF. This may be used for non-dimmable CFLs. You use the same dimming controls as for Normal mode, except that you only need to use 0 (fully off) or 1 (fully on). The TOGGLE key still retains its former action.

(3) Sleep mode

Sleep Mode functions the same as Normal mode, except that the light is gradually dimmed to off for the duration of the timeout period (when there is no IR activity).

This is useful, for example, for setting a baby to sleep. You could set the timeout period to 30 minutes, set the dimmer to sleep mode and then set the initial brightness.

While the timeout period can be anything from 1 minute to 1 week, the sleep mode function will only work with timeout periods between 1 minute and 255 minutes (4.25 hours).

(4) Flashing mode

In Flashing mode, the light will flash with a 25% duty cycle at a user-set frequency (see below). This mode is useful for a shop front display or some form of beacon application.

(5) Security mode

This mode will randomly turn the light on and off at full brilliance, for a period between five minutes and two hours. This simulates someone entering a room and turning a light on, then later turning it off, making it perfect for giving a home an ‘occupied’ appearance even though no-one is at home.

Both the on time and the off time are random; ie, they are not the same. They could be anywhere between (and including) five minutes and two hours.

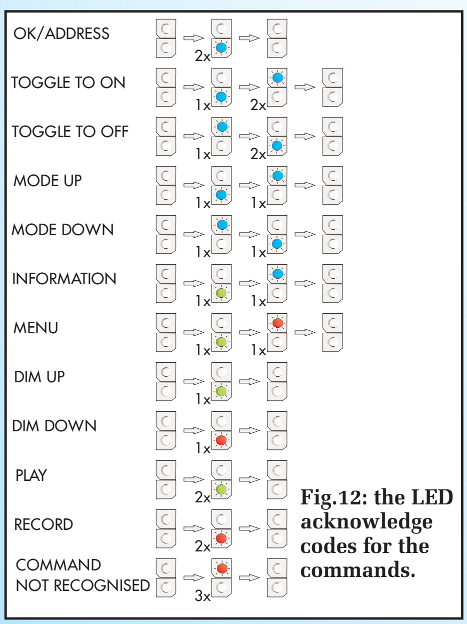


Fig.12: the LED acknowledge codes for the commands.

Menus and Information

There are a number of menus that let you change the default behaviour of the light dimmer. To enter menu X (where X is in the range 0 to 9), you press MENU + X, whereas to get information on a setting you enter INFO + X. The complete list of menus and information options is given in Table 2 and Table 3.

Timeout period

The timeout period can be set anywhere between 1 minute and 9999 minutes. Setting it to 0 disables the timeout function. To view the current timeout period, go to INFO+1, whereas to set the timeout period go to MENU+1.

For example, to set the timeout period to two hours, press MENU + 1 (then wait to enter the menu, which is acknowledged by an LED sequence – see Fig.11). Then you would type 1 + 2 + 0 + OK/ADDRESS (OK/ADDRESS is used to exit the menu).

To now view the current timeout period, type INFO + 1. You should see the LED code for +120. Table 4 shows some typical timeout periods.

Mains frequency

Pressing INFO + 3 gives the current mains frequency in units of 0.1Hz. For example, a reading of 495 indicates 49.5Hz.

Multi addressable

Setting the light dimmer’s address is easy. Simply press MENU + 4. To view the address, type INFO + 4. The address can be set anywhere between 1 and 9. Setting it to 0 (broadcast) disables the address function and makes the dimmer respond to remote control commands from any address.

If the address is set to 4, for example, the light dimmer will ignore any remote control commands (except INFO commands) not addressed to that address. This is useful if you want to control two light dimmers independently with the same remote. You simply set them to different addresses.

Suppose you set dimmer one’s address to 1 and the other to 2. If you want to make the first one listen, press OK/ADDRESS + 1. That sets the current address for all light dimmers in range. They then compare that address to their set address. If it matches, the light dimmer will not ignore the received commands.

Now any subsequent commands will be executed by dimmer 1 but ignored by dimmer 2. If you now press OK/ADDRESS + 3, assuming there is no other dimmer nearby, both will ignore any subsequent commands!

You can also disable the selective addressing by setting the dimmer’s address

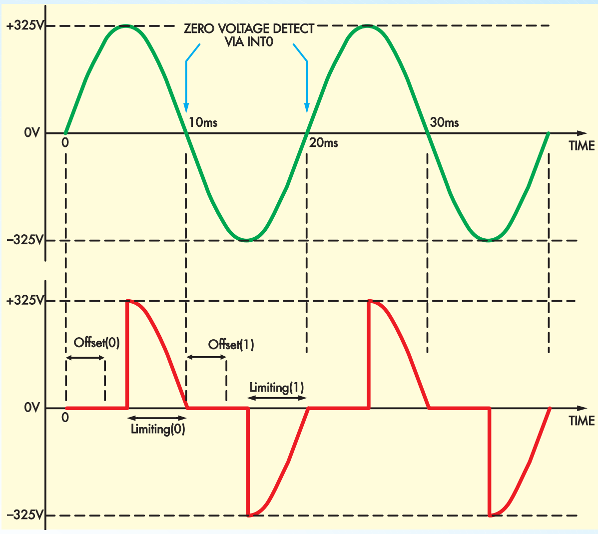


Fig.13: this explains the meaning of the four advanced settings. The offset can be a positive or a negative number, while the limiting value is a single unsigned 8-bit number.

to 0. Press MENU + 4 to enter the ADDRESS menu. Then press 0 + OK/ADDRESS to set the address to 0 and make it listen to any address.

Speed of dimming

The default value for the dimming delay is 10. This gives a period of around five seconds to dim from one extreme to another.

You can vary the speed of dimming by entering MENU + 9. Then enter the number. Possible values range from 0 (fastest) to 9999 (extremely slow).

To set the speed of dimming to take roughly 10 seconds from one extreme to another, enter the sequence MENU + 9, then wait to enter the menu, then enter 2 + 0 + OK/ADDRESS to set the dimming delay to 20. At any time, you can press INFO + 9 to see the set value. The dimming delay will be echoed back to you as a number in LED code.

Speed of flashing

In Flashing mode, the frequency of flashing can be varied by entering MENU + 2. Wait to enter the menu and then you can enter a number. The higher the number, the slower will be the flashing. A value of X gives a flashing frequency of approximately 5/(X+1) Hz. So for example, a value of 19 will give a 0.25Hz flashing frequency (or a flash roughly every four seconds).

The default flashing value is 10, giving a flashing rate of 0.45Hz (roughly one flash every two seconds).

Minimum brightness

You can set the minimum lamp brightness which will apply at all times unless the dimmer is switched off by an in-line switch.

You can set the quiescent level by pressing MENU + 3. You will then be able to set the quiescent level with the usual dimming buttons (VOL UP and VOL DOWN and the number keys). Once you are happy with the set level, press OK/ADDRESS to exit the menu.

Note that if you are using the light dimmer in the ZV mode or flashing mode, the quiescent current level will be ignored.

Save and recall options

At any time, you can use the RECORD button to store the current brightness and operating mode to non-volatile memory (EEPROM).

When you next press the PLAY button, these settings are restored. This can be used to set your favourite brightness level to be recalled at any time in one touch.

Advanced settings

The firmware of this light dimmer allows fine tuning of the triac response, in terms of four parameters that can be set by the user: two limiting values and two offset values (two each for each of the two half cycles of the mains waveform).

Note that you will not normally need to set these values, as the defaults should be suitable for most incandescent lamps, dimmable CFLs and halogen lamps. In the event that you are driving, say, a desk halogen lamp, where the 12V power is supplied by a transformer (plugpack), the load will not strictly be resistive, as the transformer would present an inductive load.

In this case, this light dimmer allows you to set these four parameters to control the triggering of the triac and to customise the dimmer response.

The limiting values 'limiting0' and 'limiting1' are 8-bit numbers ranging from 0x00 to 0xFF (hexadecimal). The default values are 0xFF or 255.

The brightness level is guaranteed to always be less than or equal to the 'limiting0' value in the positive half cycle of the mains waveform and less than or equal to the 'limiting1' value in the negative half cycle of the mains waveform.

A brightness level of N corresponds to the limiting value: $V = 28 \times N$, where N is a digit from 0-9. As a percentage, the equation becomes: $V = 2.55 \times P$, where P is the percentage of full brightness. So, for example, a brightness level of 5 corresponds to the value 140 (or roughly 55% brightness).

Suppose we want to limit the positive half cycle brightness to around 55% of full brightness. Then we would enter MENU + 5 (then wait to enter the menu). Then we would type 1 + 4 + 0 + OK/ADDRESS. This would set the limiting value for the positive half cycle to around 55%.

This gives you very fine control of the triac response.

An example: driving a 12V halogen desk lamp

Why would you ever need to change the default values? Suppose you are controlling a desk lamp with a 12V halogen bulb. The 12V is derived from a transformer in a plugpack and hence presents an inductive load to the light dimmer.

The inductive load changes the phase relationship and we found that by choosing values of limiting0 = 0×FF and limiting1 = 0×E0, we could prevent the desk lamp from flickering when set to the maximum brightness level.

The flickering occurs because the triac triggering is occurring before the zero crossing of the mains rather than after.

The offset setting is a signed 16-bit number (the default value is 0) which you can also set (it can range between –32768 to 32767). The unit is 800ns. So an offset of 1500 indicates a time offset of 1.2ms, for example. Note that a half cycle of the mains (at 100Hz) equates to a 10ms period, or in other words a full offset of 12500. *EPE*

Max's Cool Beans

By Max The Magnificent

Sugar and space and all things nice…

DO YOU remember that poem 'What are little girls and boys made of?' that originated around the early 1800s, and that our parents used to recite to us when we were kids. Apparently, little girls were made of 'sugar and spice and all things nice,' while I and my compatriots were composed of 'frogs and snails and puppy dogs' tails.'

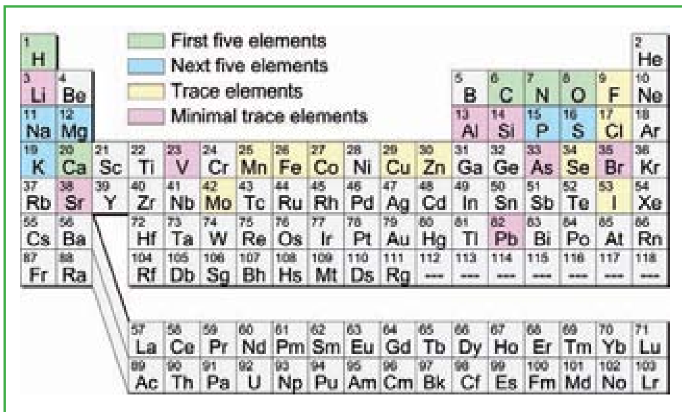


Fig.1. The elements in the human body

Have you ever wondered what we are actually made of? Recently, I've started to become very interested in 'stuff' to do with elements. I think my interest was kicked into gear when I read *The Disappearing Spoon* by Sam Kean. Since then I've started to run across all sorts of interesting nuggets of knowledge, such as the elements forming a human body (Source: H. A. Harper, V. W. Rodwell, P. A. Mayes, *Review of Physiological Chemistry*, 16th ed., Lange Medical Publications, Los Altos, California 1977.) Consider the periodic table shown in Fig.1.

The green squares represent the first (that is, the most abundant) five elements in the human body. Since we are about 70% water, it's not surprising that hydrogen (H) and oxygen (O) appear in this group. Similarly, calcium (Ca) is used to form our bones and carbon (C) is the basis of life as we know it. I must admit that I was surprised to see nitrogen (N) in the top five, but what do I know?

The blue boxes represent the next five elements in terms of abundance. These are followed by the yellow and pink boxes, which represent the trace and minimal-trace elements we need to survive, respectively. Again, there are some surprises here. Over the last few years I know that scientists have discovered that minimal amounts of arsenic (As) are essential, but I'm not sure what role lead (Pb) plays.

Elementary IC

But wait, there's more, because I also ran into some information with regard to the elements used to form integrated circuits, as illustrated in Fig.2 (Source: *Research Directions for Nano-Scale Science and Technology*, Tze-Chiang (T.C.) Chen, IBM Fellow, VP Science & Technology, Research Division).

In this case, the green boxes reflect the elements used before the 1990s; the blue boxes indicate additional elements used after the 1990s, but before 2006; and the pink boxes reflect still more elements we started to use after 2006 to the present day. I don't know about you, but I think it's interesting that there are now more elements in a high-end integrated circuit than there are in a human being.

Of course, the mind-blowing thing is that the majority of these elements were created in supernovae (stellar explosions), which means that in a very fundamental way we are all created from stardust (my dear old mother won't be surprised to hear this … she always told me I was special!)

Until next time – have a good one – Max!

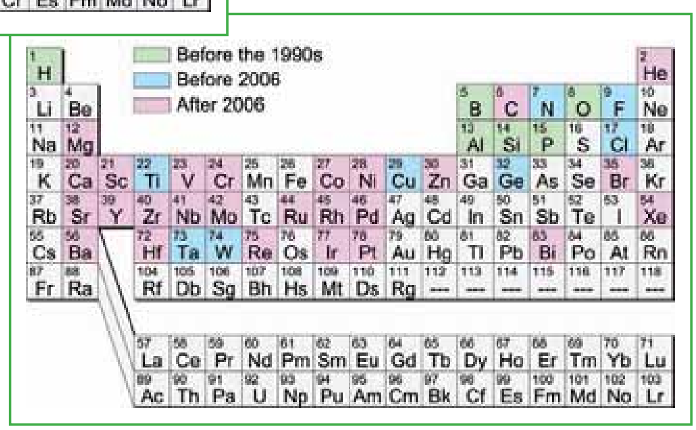


Fig.2. Elements used to form integrated circuits

Check out 'The Cool Beans Blog' at www.epemag.com

Catch up with Max and his up-to-date topical discussions

EPE EXCLUSIVE

Win a Microchip Microstick Development Board

EVERYDAY PRACTICAL ELECTRONICS is offering its readers the chance to win one of ten **Microchip** Microstick development boards for dsPIC33F and PIC24H (P/N DM330013). The Microstick for dsPIC33F and PIC24H devices is designed to provide an easy-to-use, economical development environment for 16-bit digital signal controllers and microcontrollers. The board includes an integrated debugger/programmer, a socket for the device under test and pins that facilitate insertion into a prototyping board for extremely flexible development.

The Microstick offers an integrated USB programmer/debugger, which shortens learning curves. For maximum flexibility, the Microstick can be used stand-alone or plugged into a prototyping board.

Software support includes the same free MPLAB IDE and software libraries that work with all of Microchip's 8/16/32-bit PIC microcontrollers and DSCs. Additionally, the dsPIC33F DSCs are supported by the free demo version of Microchip's Device Blocksets for the MATLAB language and Simulink environment, which work seamlessly within the MPLAB IDE. This combination of low-cost tools and free software provides an industry-leading platform for experimentation and development of smart-sensor and a host of other embedded-control applications.

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WIN ONE OF 10

Switch just about any plug-in mains-powered device when a passive infrared sensor detects a person approaching. It's easy with this low-cost and easy-to-build project.

By
JIM ROWE

PIR-Triggered Mains Switch

YOU'VE seen those lights fitted with PIR detectors which turn on when someone approaches. But what if you want to switch on something else that's mains powered?

Perhaps it's other security lighting? Possibly an AV recording or playback system? Maybe a fountain pump? Or just about anything else that can plug into a standard power point?

Think outside the box: what about a commercial display, which you'd like to spring into action when there's an audience close by? If so, then this project is for you.

We take a bog-standard (and cheap!) passive infrared detector, as used in millions of burglar alarms, and use it to safely turn on 230V AC mains device(s) for an adjustable preset period – and that period is set by you.

It's compact and easy to build, but at the same time it'll cost you much less than commercial PIR-triggered switches with similar features.

Features

Talking of features, what are these? First, it will accept trigger signals from virtually any standard low-cost PIR detector which can be located up to 20m away, if that's what you need. The two are connected together via a length of two-pair telephone cable – and the Switch Unit also provides 12V power for the PIR detector, via the same cable.

Next, the switch unit uses a heavy-duty mains-rated relay to switch the power to twin 230V AC outlets.

The relay contacts are rated for 20A, so the unit is quite capable of switching power for any likely load combination, up to the normal 10A limit of a standard power point.

Once triggered by the PIR detector, the unit can keep the power switched on for a preset period of time, which you can set to any of 10 different periods, ranging from just a few seconds to 128 minutes (over two hours).

This should make the unit suitable for many different applications, especially as it is also provided with a manual override button that can be

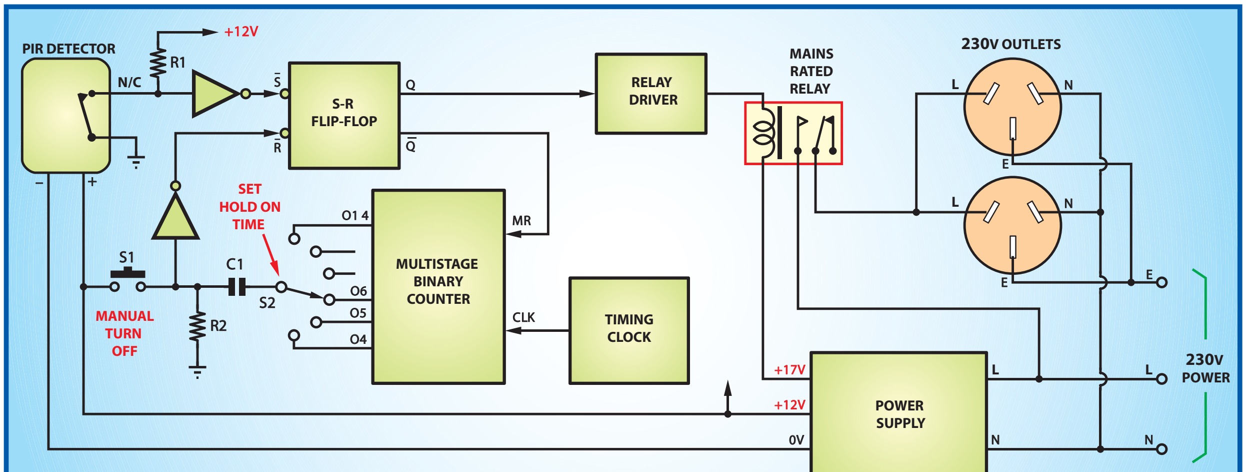


Fig.1: the block diagram of the PIR-Triggered Mains Switch. It can switch up to 10A from the two outlets (the limitation of a standard power point).

used to switch off the mains power to the load(s) at any time, regardless of the hold-on time setting.

Finally, the Switch Unit fits in a UB2-sized plastic box, with all of the low voltage circuitry on a small PC board for easy assembly.

In fact, the Switch Unit could itself be battery operated and switch low voltage devices if you like (it needs about 80mA at 12V).

In addition, the 'live' mains wiring is all off the PC board, in the interests of safety.

Before we explain how it works, this project has been sponsored by Jaycar Electronics, and kits will be available from them – see their advert in this issue.

How it works

As you can see from the block diagram of Fig.1, the project is quite straightforward. At lower right is the built-in power supply, which provides regulated 12V DC to power both the remote PIR detector and its own internal circuitry, plus an unregulated ~17V DC to power the relay.

The output of virtually all PIR detectors is a set of relay contacts, which are normally closed, but open when the detector senses movement.

It is this set of contacts which we use to trigger the mains switching unit, by connecting them between the input of a CMOS inverter and ground. The inverter input is also connected to the +12V line with resistor R1, so that whenever the detector contacts open, the inverter's input is pulled high by R1 and its output switches low.

This action is used to 'set' a set/reset flip-flop, which is normally resting in its reset state. When the flip-flop switches into the set state, its Q output switches high. This is used to activate a transistor driver circuit and energise the relay. Power is thus switched to the two 230V AC outlets and the loads.

At the same time as the S-$\overline{R}$ flip-flop switches to its set state, its $\overline{Q}$ output switches low. This output is connected to the master reset (MR) input of a multi-stage binary counter. So when the flip-flop sets, this removes the reset from the counter and allows it to begin counting. It counts the pulses from a simple clock oscillator, which runs at 0.9375Hz (the reason for this rather odd frequency will become clear in a moment).

The binary counter has 14 stages, but makes available only the outputs from internal flip-flops 4 to 10 (O4-O10) and 12 to 14 (O12-O14). We use rotary switch S2 to select one of these 10 outputs, so the rotor of S2 is kept low until the selected counter output switches high.

This happens as soon as the counter has received the appropriate number of clock pulses: eight pulses in the case of O4, 16 for O5, 32 for O6, 64 for O7 and so on, right up to O14, which only switches high after 8192 pulses have been counted.

Whenever the selected counter output switches high, this low-to-high transition is coupled via capacitor C1 into the input of a second inverter, which is normally held low by resistor R2. So the inverter's input is taken high briefly, as C1 charges up via R2. But this is long enough for the inverter's output to

This shot shows the IEC connector and PIR input on the left end of the box.

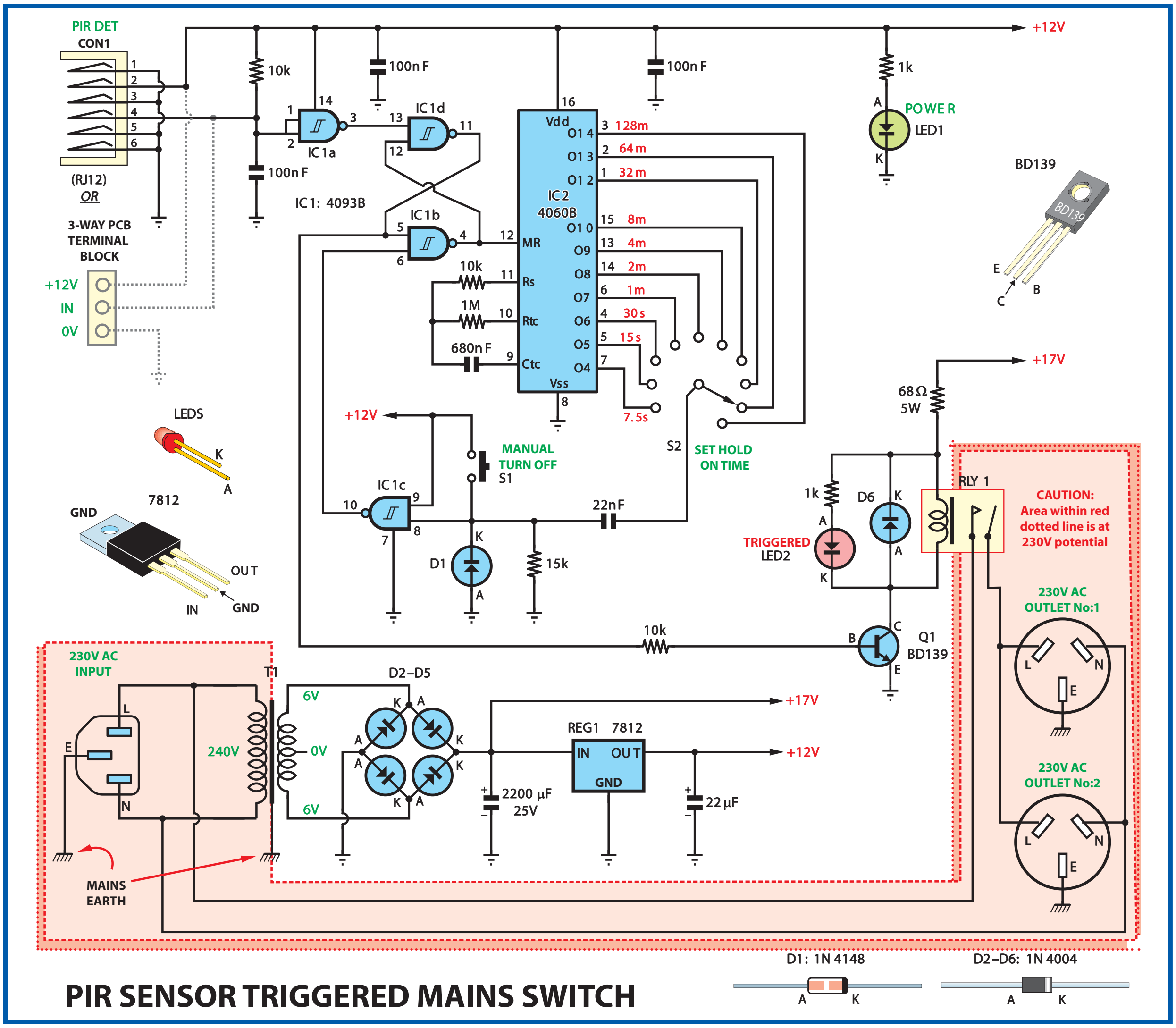


Fig.2: the circuit diagram shows how simple the PIR Mains Switch is. Note that this project switches mains, and great care MUST be taken with mains wiring. It is definitely not a project for beginners!

switch low, applying a triggering pulse to the reset input of the S-R flop-flop.

As a result the flip-flop switches back to its reset state, turning off the relay and removing 230V AC power from the loads.

So as you can see, this combination of a flip-flop and a multistage binary counter allows us to automatically turn the relay off again after an appropriate number of clock pulses has been counted – as selected by S2.

For example, if S2 is set to O4 of the counter, the relay will be turned off after eight pulses have been counted; if it's set to O5, the turnoff will be after 16 pulses; to O6 and it will be after 32 pulses and so on.

Clock oscillator

The reason for the apparently odd frequency of 0.9375Hz for the counter's clock oscillator is due to the binary relationship between all of the counter outputs.

The counter's O6 output goes high after 64 pulses have been counted, but by making the clock frequency 0.9375Hz we ensure that this corresponds to 60 seconds or one minute. (That's because 60/64 = 0.9375.)

The same clock frequency makes the switch-off times corresponding to the higher counter outputs also correspond to reasonably convenient multiples of minutes: two minutes for O8, four minutes for O9, eight minutes for O10, 32 minutes for O12, 64 minutes for 013 and 128 minutes for O14. The lower outputs also give reasonably convenient shorter times: 30 seconds for O6, 15 seconds for O5 and 7.5 seconds for O4.

But what if you have set the project to hold the power on for, say, 64 minutes after triggering and then want to switch it off immediately?

That's easily fixed, because we have also provided a normally open pushbutton switch S1, which pulls the inverter input high and causes it to reset the S-R flip-flop straight away. All you have to do to turn off the load power at any time is press S1 briefly.

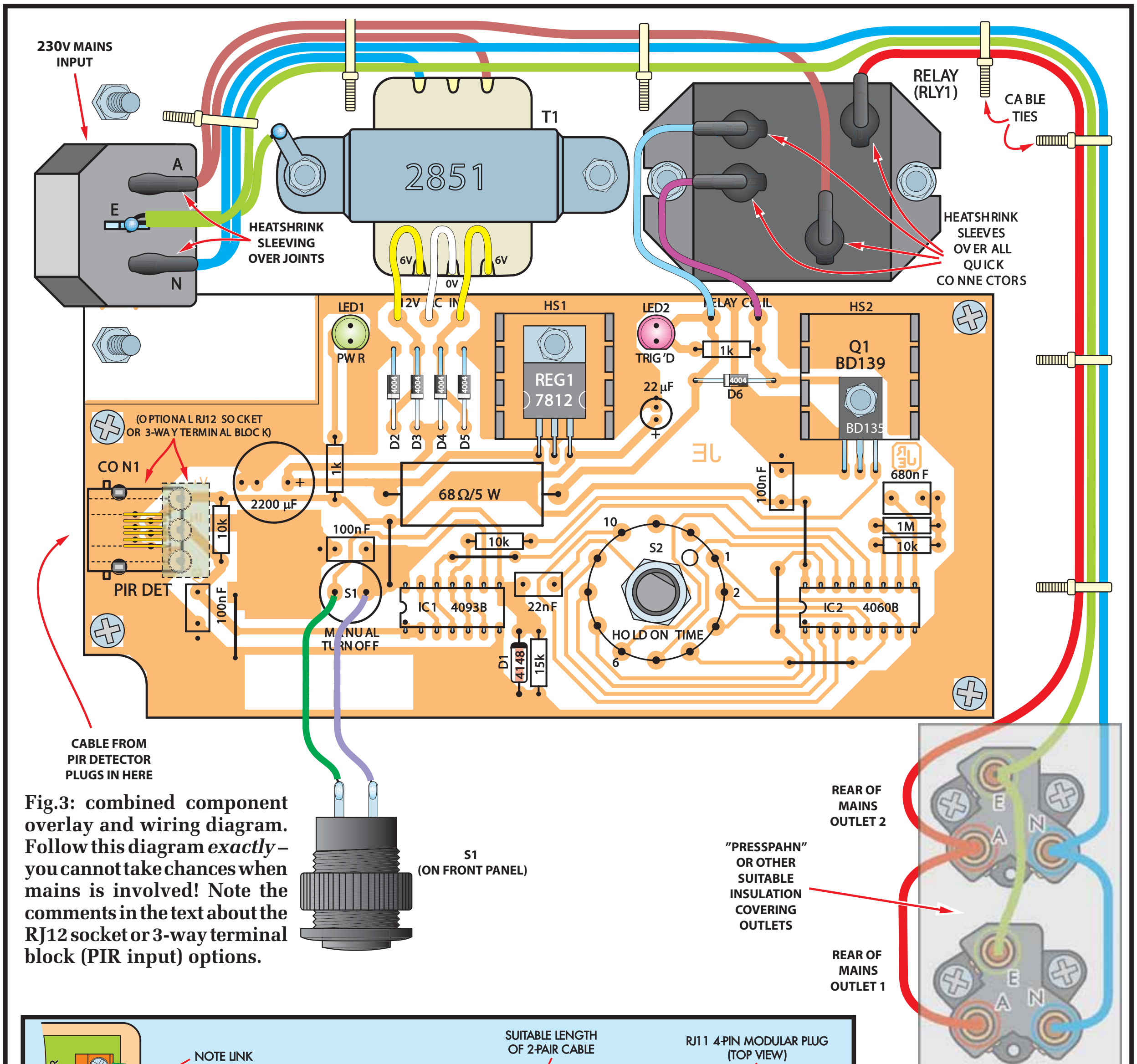


Fig.3: combined component overlay and wiring diagram. Follow this diagram *exactly* – you cannot take chances when mains is involved! Note the comments in the text about the RJ12 socket or 3-way terminal block (PIR input) options.

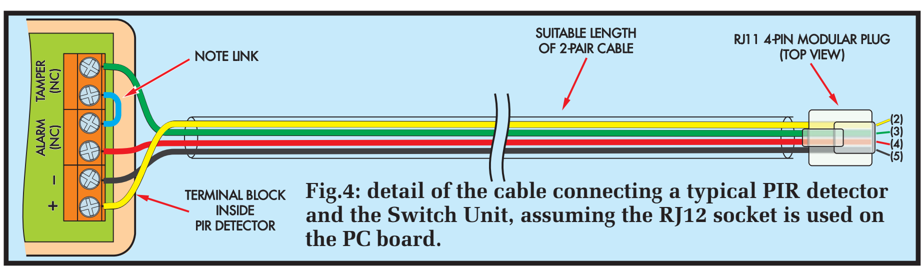
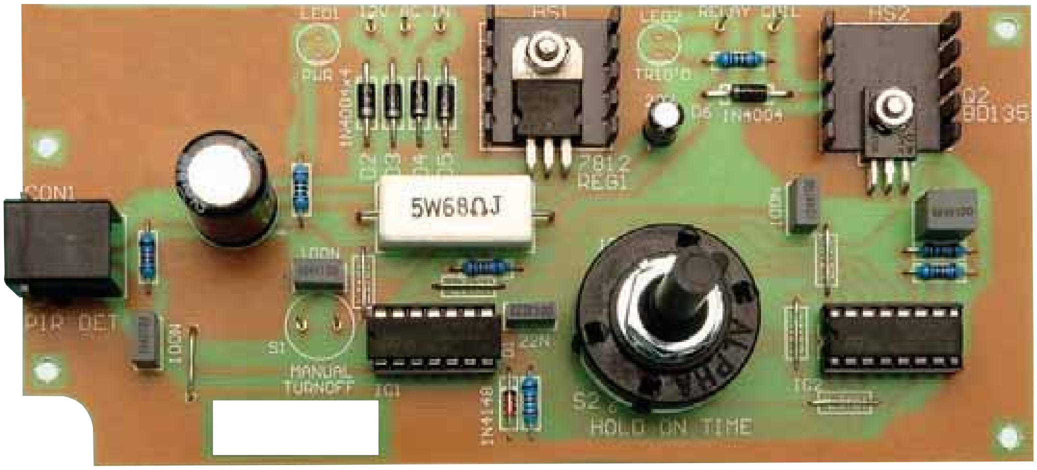


Fig.4: detail of the cable connecting a typical PIR detector and the Switch Unit, assuming the RJ12 socket is used on the PC board.

By the way, whenever the S-R flipflop is reset (and for whatever reason), this doesn't just turn off the relay and power to the load. It also re-applies a logic high to the MR input of the counter, resetting it and preventing it from counting. So the whole circuit is reset, ready to await the next trigger pulse from the PIR detector.

Circuit details

The schematic diagram shown in Fig.2 provides all of the circuit details. The PIR detector connects to the circuit via CON1, a 'modular' telephone-type connector. It receives 12V power via pins 2 and 5 of CON1, while its output (switching) contacts are connected to pins 4 and 3. Pin 4 connects to the two inputs of Schmitt gate IC1a, tied together so that it forms the input inverter. As you can see, the input pins are connected to +12V via a 10kΩ resistor (the equivalent of R1 in Fig.1), while they are also connected to ground via a 100nF capacitor to bypass any RF signals which may be picked up by the cable from the PIR detector.



Same-size photo clearly shows component placement on the PC board

(Once upon a time all we had to worry about was radio stations. Now there's TV, mobile phones, cordless phones, WiFi, Bluetooth, video/audio senders and even wireless doorbells to cause problems on long cables).

Cross-coupled gates IC1d and IC1b form the S-R flip-flop, with the output of IC1d (pin 11) forming its Q output and that from IC1b (pin 4) forming the $\overline{Q}$ output. IC2 is a 4060B device, which not only provides our 14-stage binary counter, but also its clock oscillator as well. The two resistors and 680nF capacitor connected between pins 9, 10 and 11 of IC2 set the clock frequency to 0.9375Hz. In reality, it will not be anywhere near as precise.

As explained earlier, the S-R flip-flop's $\overline{Q}$ output (pin 4 of IC1) is used to control the counter's operation by pulling the MR input of IC2 (pin 12) high to prevent counting, or pulling it low to allow it to count.

The remaining gate of IC1 (IC1c) is used to form the inverter for the S-R flip-flop's reset input. One input of this gate is tied to +12V, while the other input (pin 8) is pulled down to earth by a 15kΩ resistor (equivalent to R2 in Fig.1) and coupled to the rotor of switch S2 via a 22nF capacitor, which corresponds to C1 in Fig.1. Manual turn off switch S1 also connects between pin 8 and +12V.

Relay driver

The Q output of IC1 (pin 11) is also connected to the base of transistor Q1, via a 10kΩ series resistor. Q1 is the relay driver, which energises relay RLY1 when it conducts.

The relay coil is connected to +17V via a 68Ω 5W resistor for current limiting. Diode D6 is connected across the relay coil to protect Q1 from damage, due to the inductive 'spike' when the relay de-energises. LED2 and its 1kΩ series resistor are also connected across the relay coil, to indicate when the relay – and therefore load power – is 'ON'.

The project's power supply uses a small (2VA) power transformer T1 driving a four-diode bridge rectifier to produce the unregulated output (about 17V), which operates the relay. Regulator REG1 then derives a regulated 12V line from the rectifier output to provide power for the rest of the circuit and the PIR detector. LED1 and its series 1kΩ resistor are connected across the 12V supply to indicate when power is applied to the switch unit and PIR detector.

Construction

There are two parts to this circuit – the low voltage side (which mounts on a small PC board) and the mains wiring. The small PCB, code 798, is available from the *EPE PCB Service*.

It all fits inside a standard UB2-size (197mm × 113mm × 63mm) plastic box, with room left for the off-board (mains) components: the IEC mains input plug, power transformer T1, relay RLY1, the two flush-mount mains outlet sockets and manual turn-off switch S1.

In our prototype, the IEC mains input connector is mounted in the left-hand end of the box. However, we have been informed that production kits from Jaycar will probably have the IEC connector mounted on the front panel (the box lid) adjacent to the mains output sockets. The wiring is the same, but take the changed position into account.

Transformer T1 and the mains relay (RLY1) are bolted into the bottom of the box alongside the PC board, while the two mains outlet sockets and manual turn-off switch (S1) are mounted in the lid of the box (which forms the front panel). Rotary switch S2 actually mounts on the PC board, but its control shaft is left at its full length, so that it protrudes through a matching hole in the lid, to be fitted with a small pointer knob.

Circuit board

The overlay/wiring diagram of Fig.3 shows not only where all components go on the PC board (and their orientation), but it also shows the wiring connected to the off-board components and which joints need to be provided with heatshrink sleeves, to prevent accidental contact when the box is opened. So, if you follow all aspects of this diagram carefully, you should be able to build up the unit both safely and successfully.

Note that there are six wire links (all 0.4-inch long) to be fitted to the PC board, preferably before any of the components are fitted, because this is the easiest time to do so. After the links are fitted, it's a good idea to fit the seven PC pins, three of which are used to make the connections from the secondary of mains transformer T1; two are for the relay coil connections, while the remaining two pins are used for the wires connecting switch S1.

Next, fit the DIL sockets for IC1 and IC2, making sure you fit them with their 'notch' end towards the left, so that they'll guide you later in fitting the ICs with the correct orientation.

Now fit CON1, the RJ12 modular connector, which fits at the left-hand end of the board. A note here: the PC board pattern will also accommodate a 4-way PC-mounting screw terminal

Opened-out view of the completed project. Note the heatshrink covering any exposed mains and the Presspahn shield over the mains outlet sockets. This photo is of the first prototype, which used a DIN PIR input socket – now changed to either an RJ12 phone-type socket or a 3-way PC board screw terminal block.

block, if you would rather 'hard wire' the PIR to the PC board.

After this, fit rotary switch S2, noting that it needs to be orientated with its indexing spigot in the 'north-east' position. After mounting it, you need to remove its nut, star lockwasher and position stop plate, then refit these in reverse order after making sure the stop plate's locating pin is entering the slotted hole between the '10' and '11' numerals moulded into the top of the switch body. This is to ensure that the switch is set for 10 positions.

Once S2 is in place and set correctly, fit the various resistors and smaller unpolarised capacitors. Follow these with the 22µF and 2200µF electrolytics, which are, of course, polarised – so fit these carefully according to the overlay diagram (Fig.3).

Then fit signal diode D1 and the five power diodes D2 to D6, followed by transistor Q1 and regulator REG1. Note that both Q1 and REG1 are mounted horizontally and each device is fitted with (or on) a small U-shaped TO-220 type heatsink, with a 6mm-long M3 machine screw and nut used to clamp them in place on the top of the board.

The next components to fit to the board are LED1 and LED2. These need to have their leads extended using 25mm lengths of hookup wire, so that the body of each LED will protrude through the matching holes in the box lid when this is fitted. Use hookup wire with red insulation to extend the longer LED anode (A) leads, and wire with black insulation to extend the cathode (C) leads. Then you shouldn't have any trouble fitting the extended leads to the board correctly – the red anode leads go towards the rear of the board, and the black cathode leads towards the front.

Off-board components

Your PC board assembly is now just about complete, so place it aside while you fit the IEC mains input plug into the end of the box. It's fastened into the matching hole via a pair of 10mm long countersink-head M3 machine screws, fitted with star lockwashers and nuts on the inside. Mount the power transformer T1 in the bottom of the box, using another pair of M3 countersink-head 10mm-long screws with flat washers, star lockwashers and nuts.

Once it's in position, fit another star lockwasher to the mounting screw nearer the IEC mains plug, and then slip on a solder lug, followed by a further lockwasher and finally a second nut. Tighten this last nut firmly with a nut driver or tube spanner so there's no chance of the solder lug coming loose. (The lug is used to connect the transformer core and frame to mains earth, for safety.)

Now relay RLY1 can be bolted into the bottom of the box in much the same way, except that its plastic case needs no earthing. So in this case, just use a pair of 10mm × M3 countersink head screws with flat washers, star lockwashers and nuts.

Wiring

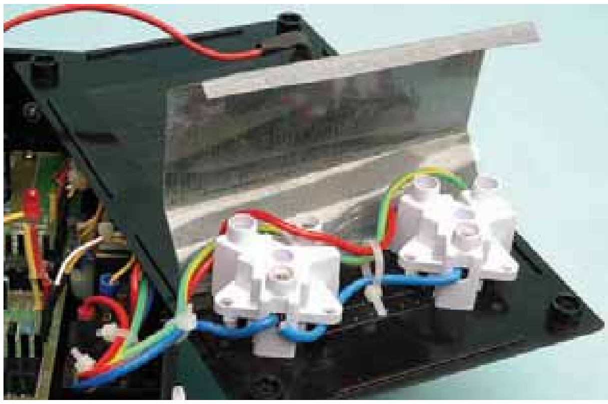
Next is a 50mm length of mains-rated figure-8 wire, used to connect S1 to the board just before the box lid is fitted. Solder one end to the PC pins marked 'S1' on the PC board and leave the other end for the moment.

We specify mains-rated cable here due to the fact that inside the box is mains wiring, which (while the chance is very remote), could possibly come loose and move around. The figure-8 itself only carries low voltage, but its insulation is mains rated to prevent any possible contact.

At this stage, you can mount the PC board assembly into the box using four 15mm-long M3 tapped spacers, with four 10mm-long × M3 countersink head nylon machine screws to attach the spacers to the bottom of the box and four 6mm-long pan head M3 screws to attach the board to the top of the spacers.

Again, nylon screws are specified 'just in case' – these screws pass from the inside of the case, where there is mains wiring, to the outside.

Then you can make the connections between the secondary winding of T1 and the three PC pins on the board just near T1. Do this by cutting all three leads to about 50mm long, removing about 6mm of insulation from the end of each



Here's a close-up view of the Presspahn insulation over the mains outlet sockets just before it was secured in place.

wire and then soldering them to the terminal pins. The two wires with yellow insulation connect to the outer pins, while the wire with white insulation connects to the centre pin.

After this, prepare two 60mm lengths of mains-rated insulated hookup wire by baring about 5mm of wire at each end, and then fitting a female 'quick connect' spade connector to one end of each wire. Next, slip a 25mm length of 6mm diameter heatshrink sleeving over each connector, and use a hot air gun or the barrel of your soldering iron to shrink the sleeves down snugly around each connector.

After this, tin the other end of each wire and finally, solder them to the PC board terminal pins just to the left of the heatsink for Q1. These wires are used to connect between the board and the relay coil lugs of RLY1 – these are the two closer-spaced lugs on its left (assuming you've fitted it the correct way around). So, once the wires have been soldered to the PC board pins, push their quick connector ends down firmly over the relay lugs as far as they'll go.

Next, fit the two flush-mounting mains outlet sockets to the lid of the box, and also fit pushbutton switch S1 into its hole in the lid near the other end. If you now turn the lid and place it near the right-hand end of the box, you should be able to add all of the remaining off-board mains wiring between the IEC mains plug, the primary winding of T1, the switching contacts of RLY1 and the mains outlets. Do this by carefully following the overlay/wiring diagram (Fig.3), which shows all of the wiring fairly clearly.

How do you know if the insulation on the cable you want to use is mains-rated? A good source of 'guaranteed' mains-rated cable is from a length of discarded mains lead. It's always handy to keep some in the junk box for purposes such as this.

Mains connector

Each of the three terminals (L, N and E) on the IEC mains input connector has two wires connected to it

First the earth: a short length of green/yellow mains-rated wire is used to make the connection between the IEC connector's centre earth lug and the solder lug fitted to the left-hand end of T1, while another much longer piece of the same wire (~160mm) is used to connect to the earth connection of each mains outlet socket. Both wires should be soldered together to the IEC plug's centre lug, to ensure a good reliable connection for them both.

Parts List – PIR-Triggered Mains Switch

1 PC board, code 798, available from the *EPE PCB Service*, size 147mm × 69mm
1 UB2-size plastic box, 197mm × 113mm × 63mm
1 PIR sensor (see text)
2 Heatsinks, 19mm square TO-220 type
1 Pushbutton switch, SPST (S1)
1 Rotary switch, 1-pole 12-position (S2)
1 Pointer knob with removable pointer inset
1 6-pin RJ12 socket, PC board mtg (CON1) or 3-way PC board mounting terminal block (see text)
1 14-pin DIL IC socket (for IC1)
1 16-pin DIL IC socket (for IC2)
1 Power transformer, 12.6V/2VA, 2851 type
1 20A mains-rated relay, chassis mtg (RLY1)
1 IEC mains plug, panel mounting
2 Mains sockets, flush mounting panel type
4 15mm-long M3 tapped spacer
10 Nylon M3 machine screws, 10mm-long CSK head
6 M3 machine screws, 6mm-long pan head
8 M3 nuts with flat and star lockwashers
1 Solder lug
8 Nylon cable ties, 100mm long
6 Quick connectors, female spade type
6 25mm lengths of 6mm diameter heatshrink tubing
7 PC board terminal pins, 1mm diameter
1 90 × 104mm piece 'Presspahn' or similar insulation

Semiconductors
1 4093B quad Schmitt NAND (IC1)
1 4060B binary counter (IC2)
1 7812 12V regulator (REG1)
1 BD139 *NPN* transistor (Q1)
1 5mm LED, green (LED1)
1 5mm LED, red (LED2)
1 1 N4148 silicon diode (D1)
5 1N4004 1A power diode (D2-D6)

Capacitors
1 2200µF 25V RB electrolytic
1 22µF 16V RB electrolytic
1 680nF metallised polyester
3 100nF metallised polyester
1 22nF metallised polyester

Resistors (0.25W 1% unless specified)
1 1MΩ 1 15kΩ 3 10kΩ 2 1kΩ
1 68Ω/5W wirewound

The design of this kit and PC board are Copyright (C) to Jaycar Electronics. Kits (cat no KC5455) will be available from Jaycar Electronics – see their ad.

The mains (live and neutral) wires are not soldered to the lugs on the IEC socket, but connected via quick-connect female spade connectors. Each of these connectors has a 25mm length of heatshrink insulation fitted so that they are completely covered. Cut two 25mm lengths of heatshrink, pass the two wires through and slide the heatshrink well up before soldering. Otherwise they may shrink from the heat of

soldering before you get them over the quick-connect spade terminals.

The 'L' terminal of the IEC connector has the brown (live) wire from the transformer primary, along with a 160mm-long mains-rated wire with brown insulation, which goes to one of the switching terminals of the relay, again via a quick-connect female spade connector. Another, similar, length of the same wire (also fitted with an insulated spade connector) goes from the other switching terminal of the relay with its opposite end going to both the 'L' screw terminals of the mains sockets.

The second primary wire from the transformer (with blue insulation) attaches via an insulated female spade terminal to the 'N' terminal of the IEC connector, along with an even longer wire (about 300mm) whose opposite end screws into both the 'N' terminals of the mains output sockets.

When you have soldered all wires to their female spade connectors, slide the lengths of heatshrink back down the wires so that the connectors are fully covered, then shrink with a heat gun. When you push the female connectors onto their appropriate male spade terminals, there must be no exposed mains wiring or metalwork visible.

Once you've completed the mains wiring, it's a good idea to tidy it all up using about six small cable ties as shown in the overlay diagram. This doesn't just make the wiring look tidier; it also helps ensure that in the unlikely event of a live wire breaking off anywhere, it can't 'wander' far enough to make contact with any of the low voltage wiring.

With the cable ties fitted, the next step is to swing the box lid around so it's just in front of the box, so you can solder the two wires coming from the PC board pins (just to the left of the socket for IC1) to the lugs on the rear of pushbutton S1. We also covered these joins in heatshrink – just in case.

Insulating shield

You will note from our photographs that we also shielded the two mains outlet sockets with an insulating material – again, just in case. In the past, the most usual material to use was a product called 'Presspahn' but that is becoming rather difficult to get these days (at least in small quantities).

We used a piece of cardboard which has a PVC insulation on one side. Other ideas that spring to mind are thin plastic or perhaps a sheet of plastic laminated paper.

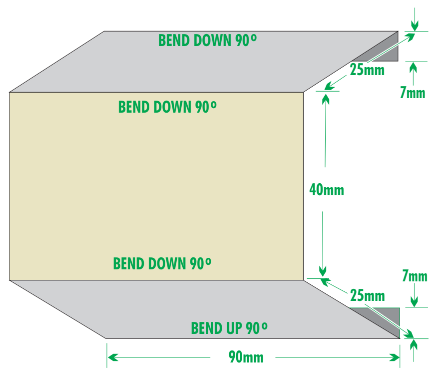


Fig.5: the detail for the insulating shield over the mains outlet sockets. It secures under the outlet backs.

The U-shaped shield, the dimension of which are shown in Fig.5, is fixed to the case by slightly undoing the mains socket mounting screws and 'sandwiching' the insulation between the back of the mains socket and the case (tightening the screws again to keep it in place).

Final assembly

After this, the final assembly step is to plug the two ICs into their sockets, making sure you fit them with their 'notch' ends towards the left in each case.

The internal wiring of your PIR Triggered Mains Switch will now be complete and you can swing the box lid up and lower it into position, carefully making sure that the control spindle of S2 and the two LEDs pass through their corresponding holes and that no internal wiring is pinched between box and lid.

You should then be able to fit the pointer knob to S2's spindle, and also screw the lid down using the four small self-tapping screws provided.

If you find the pointer on the knob doesn't point to the right place, the knob specified has a small inset plate at the top, which can be prised off and rotated to get the pointer in the correct position.

PIR wiring

There is no testing or adjustment procedure required for this project; it should operate as soon as power is applied. However, you will, no doubt, have to make up a cable to connect the project to the PIR detector unit you have chosen to use with it. Needless to say, the cable will need to be long enough to run for the distance between them.

It should be very easy to make up the cable, because we've made the connector for the Switch end an RJ12 modular socket and used only the four centre pins of it. As a result, you can make the cable easily by 'converting' a standard low-cost modular telephone extension lead, sold in lengths up to at least 15m. These leads are fitted with an RJ12 (6P/4C) plug at each end, so all you need to do is cut off the RJ12 plug at one end, and then remove the outer sleeve at that end to reveal the four wires, which will be used to connect to the PIR Detector's terminals.

The PC board also has provision for a standard 3-way terminal block if you prefer to wire the PIR detector in that way. Both inputs are shown on the overlay diagram.

The way to make the connections at the PIR Detector end of the cable is shown in Fig.4. As you can see, it's quite straightforward: the 12V power wires from pins 2 and 5 of the RJ12 plug connect to the positive and negative power terminals, while the wires from pins 3 and 4 of the plug connect to the two end terminals of the four provided for connections to the normally closed 'detect' contacts and the 'tamper' (or box opening) sensor switch. Then the two centre terminals are linked by a short length of wire, as shown, to connect the two pairs of normally closed contacts in series.

In use

That's about it. Connect up the PIR Detector to your completed Switch Unit and also connect a 230V IEC power lead to the Switch Unit's IEC input plug. At power-up you should find that the green power LED (LED1) on the Switch Unit will turn on to show that the circuit is active.

As soon as the PIR Detector senses any movement, the Switch Unit's red LED2 should also turn on to indicate that the mains switch has been triggered on. It should continue glowing for whatever period of time corresponds to the setting of switch S2 – anywhere between 7.5 seconds and 128 minutes. If you plug some lights into one of the Switch Unit's mains outlets, they should also receive power for the same period of time following a trigger event.

Check that the timing period is correct (see comment earlier about moving the pointer on the knob) and also check that pushbutton S1 turns off the load power (and LED2) when pressed. ***EPE***

A simple way to copy slides onto your computer's hard drive

A Quick'n'Easy Digital Slide 'Scanner'

Design by
BRIAN COULSON

Do you have a large collection of slides which are deteriorating by the day? Are they growing mouldy or becoming discoloured? Then there is no time to waste. Get them onto your computer's hard drive before it is too late. This method is very quick, simple and does not require any electronics.

WE'RE SURE a lot of readers would be familiar with this problem, because many people have large collections of slides (transparencies) which they have collected over the years, or boxes inherited as older generations pass on.

They're often of too much sentimental value to throw out, so they sit in the back of a cupboard somewhere, not seeing the light of day for perhaps decades.

But if you have looked at any of them recently, you may well be horrified at their deterioration. Slides suffer from two main problems – they discolour or they grow mouldy.

Preservation

So how do you preserve your priceless family history? If you don't do something soon, it may well be too late to recover any image at all. Once an image starts to deteriorate, it keeps on deteriorating. And some slide films of yesteryear are well known for deteriorating virtually from day one!

Perhaps you even have a scanner – but have been putting it off for a rainy day when you will 'get down to it'.

Unfortunately, most flat-bed scanners are not suitable for scanning slides because their light source is reflective, not transmissive. Even flat-bed scanners with transparency adaptors are seldom ideal, being a compromise.

To scan a transparency properly, you need a scanner designed for the purpose. And they don't come all that cheap (unless you can pick one up on eBay – and if you want one, there are quite a few to choose from!).

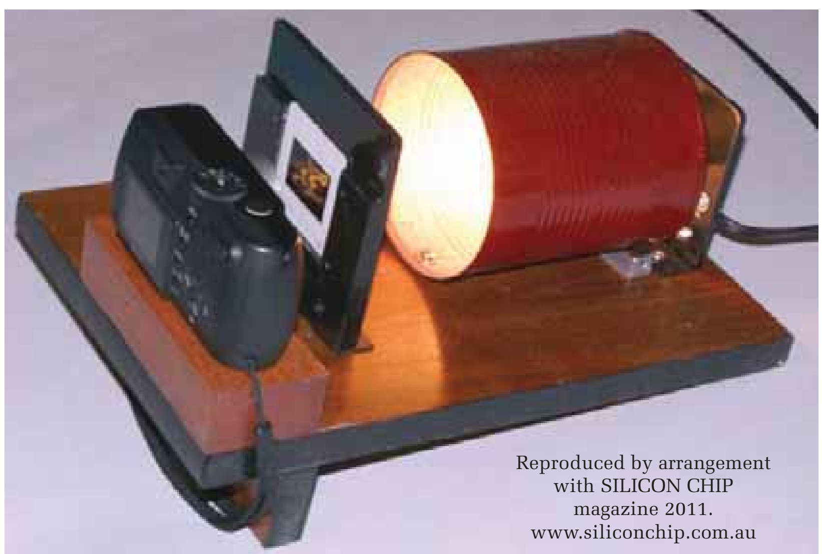
But there is a method available to anyone with a reasonable digital camera (say five megapixels or better, with a macro lens).

With that, you already have most of the solution. With the simple set-up described here, you can rapidly scan a lot of slides – much more quickly than if you used a specialised scanner.

It's cheap, and works reasonably well!

We must point out that the method described here can *never* achieve as good a result as you would get from a dedicated slide scanner.

In fact, we did an A:B comparison with our Canon slide scanner and



A light source (40W bulb mounted in a tin can!), a slide holder with an ice-cream carton lid 'neutral-density' filter and a digital camera with macro lens – that's all there is to this 'you-beaut' digital slide scanner!

Here's the result we achieved using the set-up described here. It's not too bad, considering the simplicity – but you would not be able to enlarge it much beyond postcard size. The other BIG advantage is that this took about 10 seconds to set up and capture.

For comparison, this is from our dedicated Canon 4000AS Slide Scanner. Overall, the definition is quite a lot better – but this took about ten minutes to set up, scan and save! Limitations of the offset printing process may not show the resolution, but this could be enlarged to A3+ without problems.

found that while the method works, and is fast, the comparison of quality of resultant picture is chalk and cheese, especially if you want to enlarge the image beyond postcard size.

We've reproduced a couple of images from our experiments to show the difference. We used both a 5MP Fuji 'happy snap' (albeit with macro function) and a 6MP Nikon DSLR fitted with a quality macro lens.

There wasn't much difference. We found that we could print both to postcard size; any larger and the quick method resulted in quite markedly inferior results.

Having said that, we know that by far the lion's share of prints made from digital images are no bigger than postcard size, so this limitation may not even be of much concern. It's certainly good enough to share among family members.

If you have a digital camera, give it a go: you have nothing to lose except a bit of time!

The set-up

The complete set-up consists of a digital camera, a slide holder, which doubles as a glare shield and a light source. The camera shown in these photos is a Ricoh 3MP with macro. Its minimum focus distance (macro) is 12mm. It was used in the macro mode; the distance from the lens (extended) to the slide was about 25mm. But as already noted, we think you should use a five-megapixel camera as a minimum (they are becoming remarkably cheap these days).

The method is very simple. A slide is placed in the holder, which is backlit by a standard 230V/240V AC 40W incandescent bulb. A neutral density filter placed behind the slide stops it getting too hot, while at the same time ensures that the light is evenly distributed.

The camera is focussed onto the slide, you press the button and you are done. You only have to focus the camera once, as it remains in position for each shot.

Once you get into the swing of things, removing and replacing slides and pressing the shutter button, you can scan slides at the rate of one every few seconds.

You can certainly get through a batch of a few hundred in under an hour. Take it from us; this is very much faster than you could do it with a specialised slide scanner.

After you have done a batch, you can download the shots into your computer for further processing with Photoshop or similar photo-processing software.

You could then print them on your own colour inkjet or laser, or simply take a CD or flash memory stick to the local digital processor to get them printed.

The slide holder is very basic and we are sure that readers will be able to come up with more refined versions, if they wish. As you can see from the photo, it consists of a piece of timber with a block at one end to place it on a slope. The slide holder was made from two pieces of '3-ply', with appropriate cutouts, glued together. Note that the holder is open on the camera side, which makes for faster loading of the slide.

Having the unit on a slope helps hold the slide in position, as well as making it easier to view the camera's rear fixed screen. Although the featured camera only has auto focus in the macro mode, this did not prove a problem, as it focuses in about a second.

The overall dimensions of the slide holder may seem larger than necessary, but it also functions as a light shield when you are working at the camera end.

Light source

The light source is a standard clear 40W Crompton Fancy Round incandescent lamp, mounted in a standard cordgrip lampholder and fitted inside an 825ml fruit tin. The clear lamp was found to give better lighting than a 40W frosted lamp.

The fruit tin protects the light from physical damage and prevents contact with the very hot bulb. The tin itself gets quite hot, but not nearly as hot as the naked bulb, and it prevents local glare and light flare.

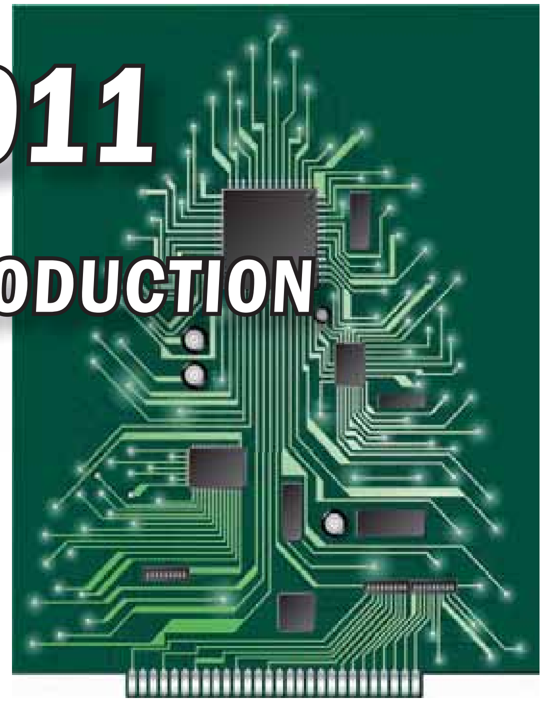
The neutral density diffuser on the slide holder is a piece of white plastic cut from an ice-cream container.

So there you are: a crude and simple jig for scanning all those slides. It does not need to be anything fancy, although we would be inclined to make a better mounting arrangement for the camera, so that if it is set up for fixed focus, it will not move around while you shoot each slide.

Our thanks to Brian Coulson for coming up with this very simple set-up. ***EPE***

TEACH-IN 2011

A BROAD-BASED INTRODUCTION TO ELECTRONICS



Part 6: Logic circuits

By Mike and Richard Tooley

Our Teach-In series is designed to provide you with a broad-based introduction to electronics. We have attempted to provide coverage of three of the most important electronics units that are currently studied in many schools and colleges in the UK. These include Edexcel BTEC Level 2 awards, as well as electronics units of the new Diploma in Engineering (also at Level 2). The series will also provide the more experienced reader with an opportunity to 'brush up' on specific topics with which he or she may be less familiar.

Each part of our Teach-In series is organised under five main headings; Learn, Check, Build, Investigate and Amaze. Learn will teach you the theory, Check will help you to check your understanding, and Build will give you an opportunity to build and test simple electronic circuits. Investigate will provide you with a challenge which will allow you to further extend your learning, and finally, Amaze will show you the 'wow factor'!

IN THIS instalment of *Teach-In* we introduce the basic building blocks of digital circuits. We explain the operation of each of the most common types of logic gate and show how they can be combined together in order to solve more complex logic problems. We also introduce bistable circuits and show how they can be used to remember a momentary event.

We shall be using Circuit Wizard to investigate each of the basic logic gates before moving on to explore some applications. Finally, in ***Amaze*** we look at how recent advances in technology have provided us with digital circuits that are capable of operation at speeds that are increasingly fast.

Learn

Digital logic

Logic circuits are the basic building blocks of *digital* circuits and systems. Logic circuits have inputs and outputs that can only exist in one of two discrete states, variously known as 'on' and 'off', 'high' and 'low', or '1' and '0'.

Logic circuits usually have several inputs and one or more outputs. At any instant of time, the state of the inputs will determine the state of the output, according to the *logic function* provided by the circuit.

If this is beginning to sound a little complicated, let's look at a couple of simple logic functions that can be satisfied using nothing more than a couple of switches and a lamp and battery.

Consider the circuit shown in Fig.6.1. In this circuit, a battery is connected to a lamp via two switches, A and B. It should be obvious that the lamp will only operate when both of the switches are closed (ie, both A AND B are closed).

Let's look at the operation of the circuit in a little more detail. Since there are two switches (A and B) and there are two possible states for each switch (open or closed), there is a total of four possible conditions for the circuit. We have summarised these *states* in Fig.6.2.

Note that the two states (ie, open or closed) are mutually exclusive

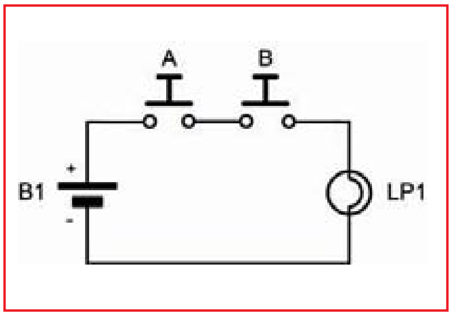


Fig.6.1. AND switch and lamp logic

Switch A	Switch B	Lamp LP1
Open	Open	Off
Open	Closed	Off
Closed	Open	Off
Closed	Closed	On

Fig.6.2. Possible states for the circuit of Fig.6.1

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Fig.6.3 (right). Truth table for the AND switch and lamp logic

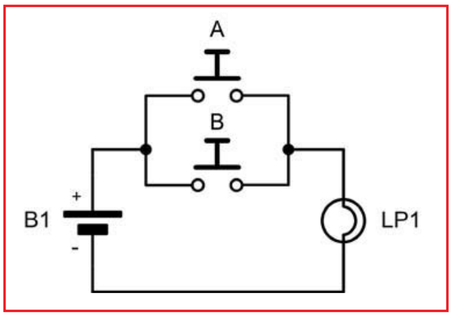


Fig.6.4. OR switch and lamp logic

Switch A	Switch B	Lamp LP1
Open	Open	Off
Open	Closed	On
Closed	Open	On
Closed	Closed	On

Fig.6.5. Possible states for the circuit of Fig. 6.4

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

Fig.6.6 (right). Truth table for the OR switch and lamp logic

and that the switches cannot exist in any other state than completely open or completely closed. Because of this, we can represent the state of the switches using the binary digits, 0 and 1, where an open switch is represented by 0 and a closed switch by a 1. Furthermore, if we assume that 'no light' is represented by a 0 and 'light on' is represented by a 1, we can rewrite Fig.6.2 in the form of a *truth table*, as shown in Fig.6.3.

Another circuit with two switches is shown in Fig.6.4. This circuit differs from that shown in Fig.6.1 by virtue of the fact that the two switches are connected in parallel rather than in series. In this case, the lamp will operate when *either* of the two switches is closed (in other words, when A OR B is closed).

As before, there is a total of four possible conditions for the circuit. We can summarise these conditions in Fig.6.5. Once again, adopting the convention that an open switch can be represented by 0 and a closed switch by 1, we can rewrite the truth table in terms of the binary states, as shown in Fig.6.6.

The basic logic functions can be combined to produce circuits that satisfy a more complex logical operation. For example, Fig.6.7 shows a simple switching circuit in which the lamp will operate when switch A AND either switch B OR switch C is closed. The truth table for this arrangement is shown in Fig.6.8.

Logic gates

Logic gates are building blocks that are designed to produce the basic logic functions, AND, OR, NOT, etc. These circuits are designed to be interconnected into larger, more complex, logic circuit arrangements.

Each gate type has its own symbol and we have shown both the British Standard (BS) symbol together with the more universally accepted American Standard (MIL/ANSI) symbol. Note that, while inverters and buffers each have only one input, exclusive-OR gates have two inputs and the other basic gates

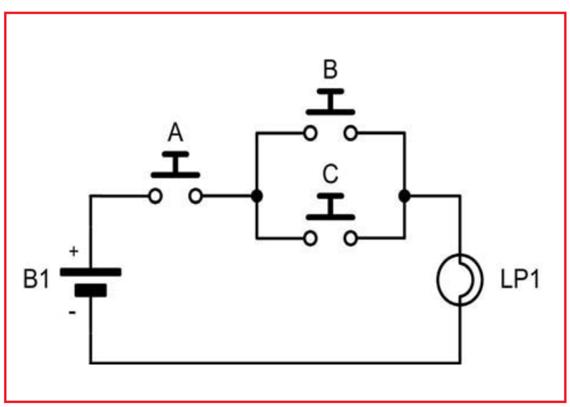


Fig.6.7. Simple switching circuit using AND and OR logic

A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Fig.6.8 (right). Truth table for the simple switching circuit shown in Fig.6.7

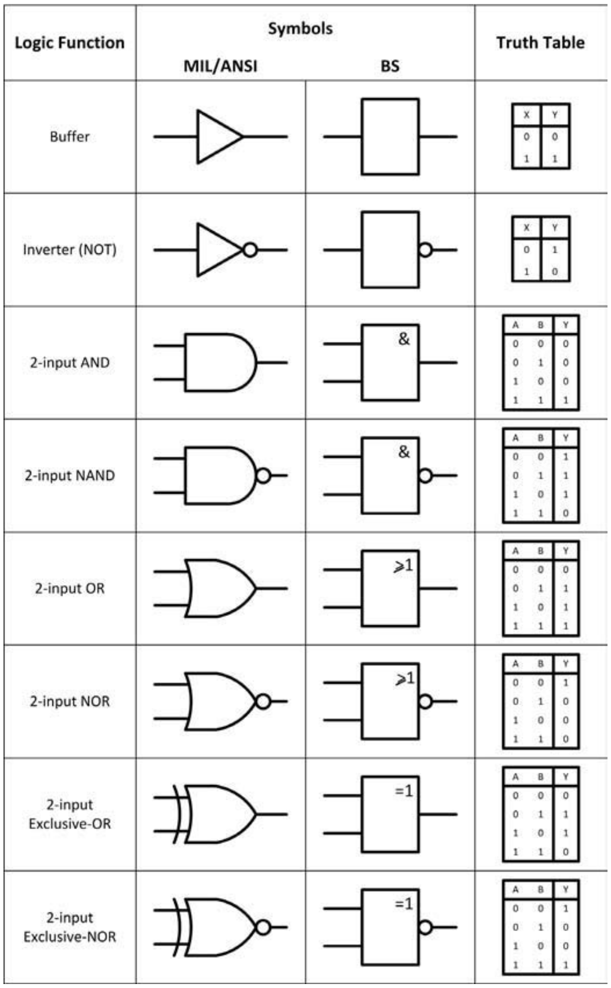


Fig.6.9. Logic gate symbols and truth tables

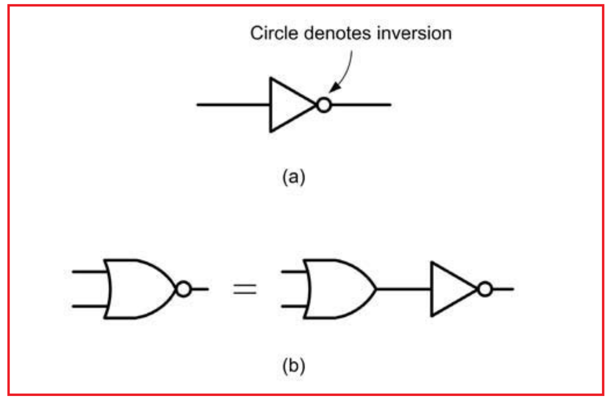


Fig.6.10. Logic gates with inverted outputs

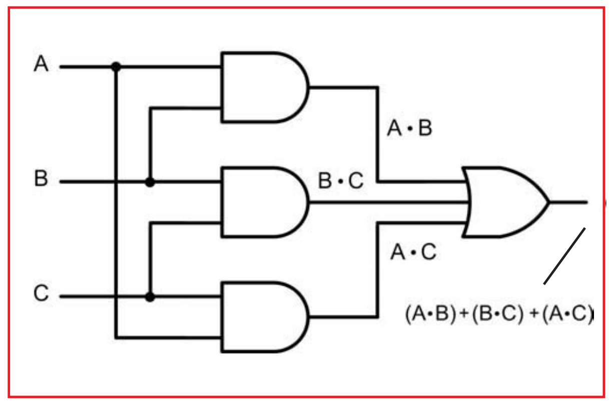


Fig.6.11 (above). Majority vote logic circuit

Fig.6.12 (right). Truth table for the majority vote logic circuit

A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

(eg, AND, OR, NAND and NOR) are commonly available with up to eight inputs.

Some of the logic gates shown in Fig.6.9 have *inverted* outputs. These gates are the NOT, NAND, NOR, and Exclusive-NOR and the small circle at the output of the gate (see Fig.6.10a) indicates this inversion. It is important to note that the output of an inverted gate (eg, NOR) is identical to that of the same (ie, non-inverted) function with its output connected to an inverter (or NOT gate) as shown in Fig.6.10b).

The logical function of a logic gate can also be described using Boolean notation. In this type of notation, the OR function is represented by a '+' symbol, the AND function by a '•' sign, and the NOT function by an overscore or '/'. Thus the output, Y, of an OR gate with inputs A and B can be represented by the Boolean algebraic expression:

$$Y = A + B$$

Similarly, the output of an AND gate can be shown as:

$$Y = A \bullet B$$

We shall now briefly summarise the logic functions of each of the basic logic gates that we met earlier in Fig.6.9:

Buffers

Buffers do not affect the logical state of a digital signal (ie, a logic 1 input results in a logic 1 output, and a logic 0 input results in a logic 0 output). Buffers are normally used to provide extra current drive at the output, but can also be used to regularise the logic levels present at an interface. The Boolean expression for the output, Y, of a buffer with an input, X, is Y = X.

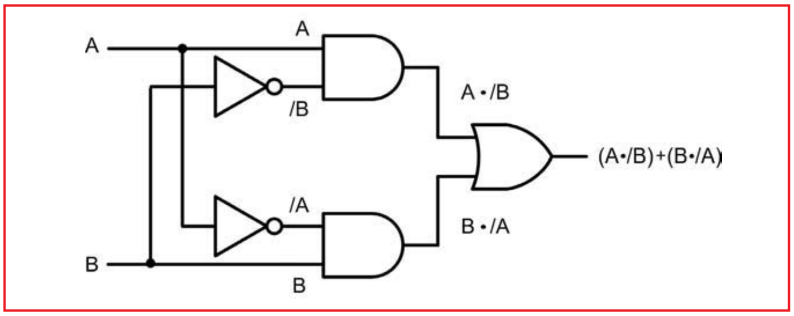


Fig.6.13. An exclusive-OR gate produced from AND, OR and NOT gates

Inverters

Inverters are used to *complement* the logical state (ie, a logic 1 input results in a logic 0 output and *vice versa*). Inverters also provide extra current drive and, like buffers, are used in interfacing applications where they provide a means of regularising logic levels present at the input or output of a digital system. The Boolean expression for the output, Y, of an inverter with an input, X, is Y = /X.

AND gates

AND gates will only produce a logic 1 output when all inputs are simultaneously at logic 1. Any other input combination results in a logic 0 output. The Boolean expression for the output, Y, of an AND gate with inputs, A and B, is Y = A • B.

OR gates

OR gates will produce a logic 1 output whenever any one, or more inputs are at logic 1. Putting this another way, an OR gate will only produce a logic 0 output whenever all of its inputs are simultaneously at logic 0. The Boolean expression for the output, Y, of an OR gate with inputs, A and B, is Y = A + B.

NAND gates

NAND (ie, NOT-AND) gates will only produce a logic 0 output when all inputs are simultaneously at logic 1. Any other input combination will produce a logic 1 output. A NAND gate, therefore, is nothing more than an AND gate with its output inverted! The circle shown at the output denotes this inversion. The Boolean expression for the output, Y, of a NAND gate with inputs, A and B, is $Y = \overline{A \bullet B}$.

NOR gates

NOR (ie, NOT-OR) gates will only produce a logic 1 output when all inputs are simultaneously at logic 0. Any other input combination will produce a logic 0 output. A NOR gate, therefore, is simply an OR gate with its output inverted. A circle is again used to indicate inversion. The Boolean expression for the output, Y, of a NOR gate with inputs, A and B, is $Y = \overline{A + B}$.

Exclusive-OR gates

Exclusive-OR gates will produce a logic 1 output whenever either one of the two inputs is at logic 1 and the other is at logic 0. Exclusive-OR gates produce a logic 0 output whenever both inputs have the same logical state (ie, when both are at logic 0 or both are at logic 1). The Boolean expression for the output, Y, of an exclusive-OR gate with inputs, A and B, is Y = (A • /B) + (B • /A).

Exclusive-NOR gates

Exclusive-NOR gates will produce a logic 0 output whenever either one of the two inputs is at logic 1 and the other is at logic 0. Exclusive-NOR gates produce a logic 1 output whenever both inputs have the same logical state (ie, when both are at logic 0 or both are at logic 1). The Boolean expression for the output, Y, of an exclusive-NOR gate with inputs, A and B, is

$$Y = \overline{(A \bullet /B) + (B \bullet /A)}$$

Combinational logic

The basic logic gates can be combined together to solve more complex logic functions. This is made possible by adopting a standard range of logic levels (ie, voltage levels used to represent the logic 1 and logic 0 states) so that the output of one logic circuit is compatible with the input of another.

As an example, let's assume that we require a logic circuit that will produce a logic 1 output whenever two, or more, of its three inputs are at logic 1. This circuit (shown in Fig.6.11) is often referred to as a *majority vote* circuit, and its truth table is shown in Fig.6.12.

Note that the outputs of the three two-input AND gates are fed to the three inputs of the OR gate, and that the output of the OR gate will become logic 1 whenever any one or more of the two-input AND gates detects a condition in which two of the inputs are simultaneously at logic 1.

As a further example, consider how we might combine several of the basic logic gates (AND, OR and NOT) in order to realise the exclusive-OR function. In order to solve this problem, consider the Boolean expression for the exclusive-OR function that we met earlier:

Y = (A • /B) + (B • /A)

/A and /B can be obtained by simply inverting A and B respectively. Then, A • /B and B • /A can be obtained using two two-input AND gates. Finally, these two can be applied to a two-input OR gate in order to obtain the required logic function, (A • /B) + (B • /A). The complete solution is shown in Fig.6.13.

Bistables

Bistable circuits provide us with a means of remembering a transient logic condition. For example, the logic that controls a lift must remember that the lift has been called in response to a push-button that only requires momentary operation.

As its name suggests, the output of a bistable (or *flip-flop*) circuit has two stables states (logic 0 or logic 1). Once *set*, the output of a bistable will remain at logic 1 or logic 0 for an indefinite period, or until the bistable is *reset*. A bistable thus forms a simple form of memory, remaining in its latched state (either set or reset) until a signal is applied to it to change its state (or until the supply is disconnected).

The simplest form of bistable is the R-S bistable. This device has two inputs, SET and RESET, and complementary outputs, Q and $\overline{Q}$. A logic 1 applied to the SET input will cause the Q output to become (or remain at) logic 1, while a logic 1 applied to the RESET input will cause the Q output

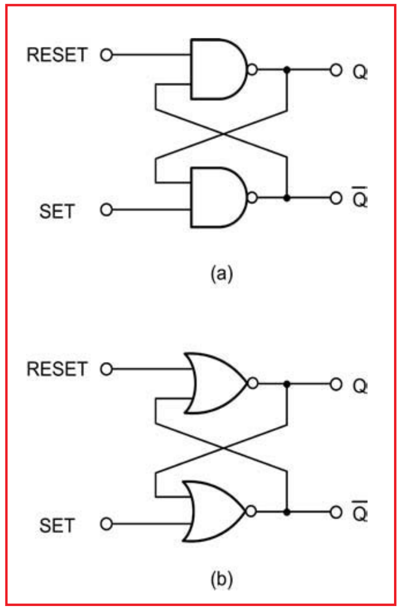


Fig.6.14. Simple R-S bistables (a) based on NAND gates and (b) based on NOR gates

to become (or remain at) logic 0. In either case, the bistable will remain in its SET or RESET state until an input is applied in such a sense as to change the state. Note also that the Q and $\overline{Q}$ outputs always have opposite logical states. Thus, when the Q output is at logic 1 the $\overline{Q}$ output will be at logic 0, and *vice versa*.

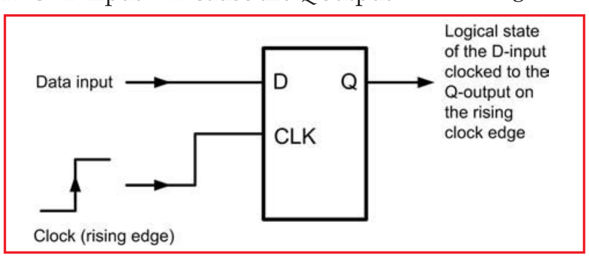


Fig.6.15. D-type bistable

Two simple forms of R-S bistable based on cross-coupled logic gates are shown in Fig.6.14. Fig.6.14(a) is based on two cross-coupled two-input NAND gates, while Fig.6.14(b) is based on two cross-coupled two-input NOR gates.

D-type bistable

Unfortunately, the simple cross-coupled logic gate bistable has a number of serious shortcomings (consider what would happen if a logic 1 was simultaneously present on both the SET and RESET inputs!) and practical forms of bistable make use of much improved purpose-designed logic circuits, such as D-type and J-K bistables.

The D-type bistable has two inputs: D (standing variously for *data* or *delay*) and CLOCK (CLK). The data input (logic 0 or logic 1) is clocked into the bistable such that the output state only changes when the clock changes state. Operation is thus said to be synchronous. Additional subsidiary inputs (which are invariably active low) are provided, which can be used to directly set or reset the bistable. These are usually called PRESET (PR) and CLEAR (CLR). D-type bistables are used both as latches (a simple form of memory) and as binary dividers. The simple circuit arrangement in Fig.6.15, together with the timing diagram shown in Fig. 6.16 illustrate the operation of D-type bistables.

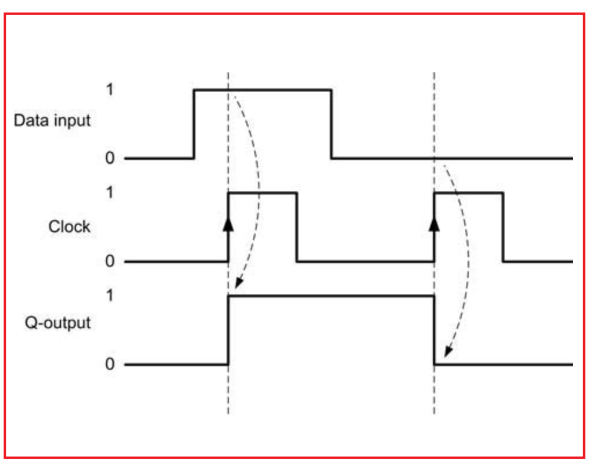


Fig.6.16. Timing diagram for the D-type bistable

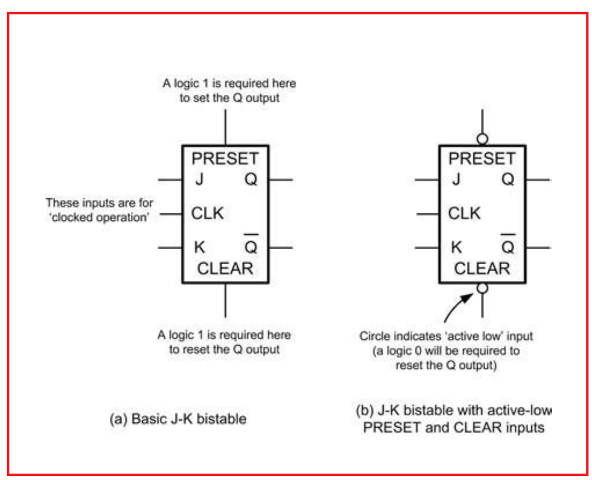


Fig.6.17. J-K bistable

J-K bistables

J-K bistables (see Fig.6.17) have two clocked inputs (J and K), two direct inputs (PRESET and CLEAR), a CLOCK (CK) input, and outputs (Q and $\overline{Q}$). As with R-S bistables, the two outputs are complementary (ie, when one is 0 the other is 1, and *vice versa*). Similarly, the PRESET and CLEAR inputs are invariably both active low (ie, a 0 on the PRESET input will set the Q output to 1, whereas a 0 on the CLEAR input will set the Q output to 0). Fig.6.18 summarises the input and corresponding output states of a J-K bistable

Inputs		Output	Comment
PRESET	CLEAR	Q	
0	0	?	Indeterminate
0	1	0	Q output changes to 0 (ie, Q is reset) regardless of the clock
1	0	1	Q output changes to 1 (ie, Q is reset) on the next clock transition)
1	1	-	Enables clocked operation - refer to the next truth table

Note that the PRESET and CLEAR inputs are unaffected by the state of the clock

(a) PRESET and CLEAR inputs

Inputs		Output	Comment
J	K	Q_{N+1}	
0	0	Q_N	No change in state of the Q output on the next clock transition
0	1	0	Q output changes to 0 (ie, Q is reset) on the next clock transition)
1	0	1	Q output changes to 1 (ie, Q is reset) on the next clock transition)
1	1	Q_N	Q output changes to the opposite state on the next clock transition

Note that Q_N means 'Q in whatever state it was before, while Q_{N+1} means 'Q after the next clock transition'

(b) Clocked operation using the J and K inputs

Fig.6.18. J-K bistable operation

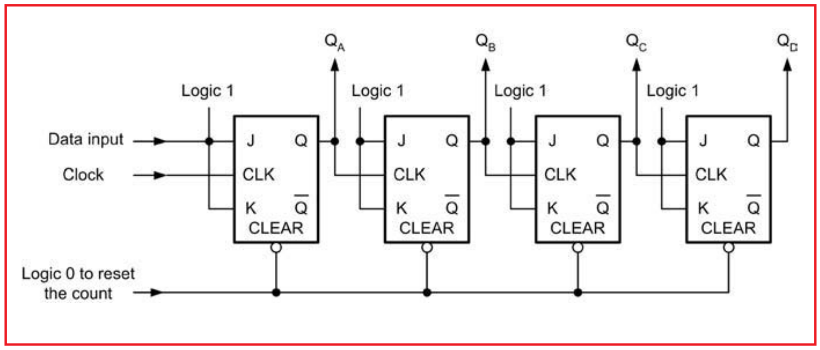


Fig.6.19. Circuit for a four-stage binary counter using J-K bistables

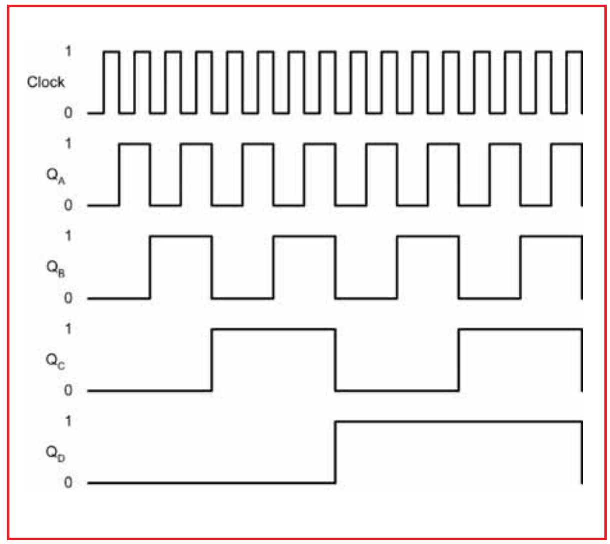


Fig.6.20. Timing diagram for the four-stage binary counter of Fig.6.19

for various input states. J-K bistables are the most sophisticated and flexible of the bistable types, and they can be configured in various ways, including binary dividers, shift registers, and latches.

The circuit arrangement of a four-stage binary counter, based on J-K bistables, is shown in Fig.6.19. The timing diagram for this circuit is shown in Fig.6.20. Each stage successively divides the clock input signal by a factor of two. Note that a logic 1 input is transferred to the respective Q-output on the falling edge of the clock pulse, and all J and K inputs must be taken to logic 1 to enable binary counting.

Practical logic circuits

You should now have a basic grasp of the theory of logic circuits, but what we haven't done yet is give you an idea of what these devices look like and how they appear in practical logic circuits. So, let's end this month's ***Learn*** by showing you two examples of modern logic circuits. The first of these is a 4013 dual D-type bistable, while the second is a 74F08 quad two-input NAND gate.

The 4013 dual D-type bistable is supplied in various packages, including the dual-in-line (DIL) package shown in Fig.6.21. This device uses standard complementary metal oxide semiconductor (CMOS) technology, and its pin connections are shown in Fig.6.22. Note that pin 14 and pin 7 supply power to both of the D-type bistables.

The 74F08 quad two-input NAND gate is also available in several different packages. We have shown the small integrated circuit (SOIC) package in Fig.6.23. This package is ideal for surface mounting rather than through-hole mounting used with the DIL package that we met before. The 74F08 contains four independent NAND gates and uses 'fast' transistor-transistor logic (TTL). The pin connection diagram for the chip is shown in Fig.6.24. As with the 4013, the supply connections (pin 14 and pin 7) are common to all four of the internal logic gates.

Fig.6.21. A 4013 dual D-type bistable in a plastic dual-in-line (DIL) package. This chip was manufactured in 1992

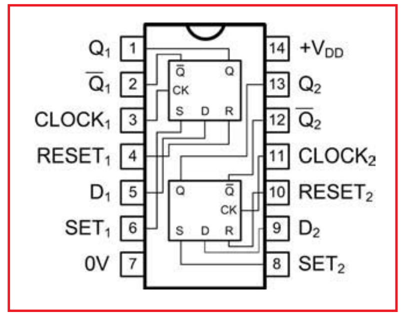


Fig.6.22. Pin connections for the 4013 dual D-type bistable IC

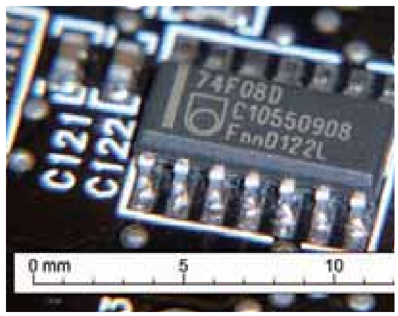


Fig.6.23. A 74F08 quad two-input NAND gate in a small surface-mount package (SOIC). This chip was manufactured in 2001

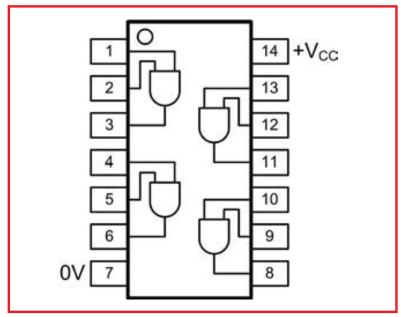


Fig.6.24. Pin connections for the 74F08 quad two-input NAND gate IC

Please note!

Some logic devices, particularly CMOS types, are static-sensitive and special precautions are needed when handling and transporting them.

Check – How do you think you are doing?

6.1. Identify each of the logic symbols shown in Fig.6.25

6.2. Draw the truth table for the logic gate arrangement shown in Fig. 6.26.

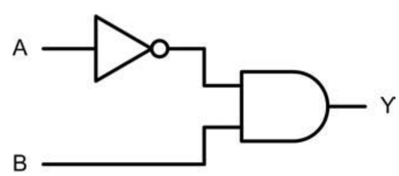


Fig.6.26. See Question 2

6.3. Show how three two-input AND gates can be connected together to form a four-input AND gate.

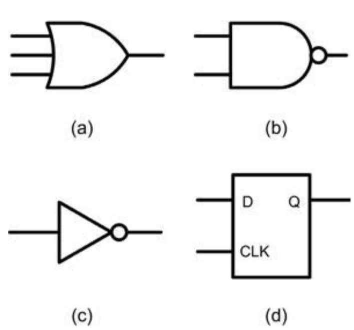


Fig.6.25. See Question 1

6.4. State the Boolean logic expression for the output of each of the gate arrangements shown in Fig.6.27 – opposite.

6.5. Devise a logic gate arrangement that provides an output described by the truth table shown in Fig.6.28.

A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Fig.6.28. See Question 5

Build – The Circuit Wizard way

YOU'VE learnt the theory about logic gates, so now let's try it out using Circuit Wizard. Anyone who's experimented or prototyped with discrete logic circuits before will be all too familiar with hopelessly prodding a logic probe into an incomprehensible 'rat's nest' of breadboard and link wires.

Fortunately, nowadays we can do all this and more using software packages before we commit any copper to PCB. Circuit Wizard really does have a few aces up its sleeve when it comes to working with logic.

First, you can work directly with the logic gates themselves and let it worry about the chip packages (see later on), as well as a number of dedicated inputs/outputs and simulation schemes that bring the circuits to life and visually convey what's really going on in the circuit. In this instalment of ***Build*** we'll be trying out some logic gates to see how they operate, as well as experimenting with some real life applications.

Opening the gates

Circuit Wizard includes a large range of logic devices in both CMOS and TTL versions (note that the extent of the logic devices may depend on the version of Circuit Wizard that you are running).

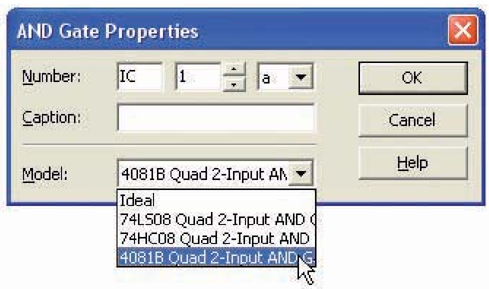


Fig.6.29. Changing logic families for a logic gate

The first thing that you may notice is that in the Gallery (right-hand panel) you can access standard and Schmitt varieties of gates in the 'Logic Gates' folder, as well as each family of chip separately in the 'Integrated Circuits' folder. We can only assume that this is for the purpose of providing quick access to the more common gates.

By default, 4000 series ICs will be used. However, you are able to select the family of gate by selecting the appropriate model in the properties context box; see Fig. 6.29 (double-click the component to access this). This default behaviour can also be altered in the software's setting if required.

Gate numbers

When you add a gate to the drawing area you should notice that it will automatically number your gate in accordance with the corresponding IC required. As each IC contains a number of gates, an alphabetical suffix will be added to the chip reference (eg, IC1a) to show which has been allocated. Once the total number of gates has exceeded that of the IC, Circuit Wizard will automatically include a new chip, and so on.

You are able to change which gate has been allocated within the chip. This can be useful when it comes to generating the most efficient PCB layout.

However, the automatic allocation works great for most users. Circuit Wizard will also add power connections 'in the background', so that these are accounted for in net lists when moving on to PCB generation.

The best way to understand the operation of the basic gates is to drop one on to the drawing area, add inputs and outputs and see how the output changes in response to changes in the inputs. Circuit Wizard has some really useful input toggles and output indicators which can be found at the top of the 'Logic Gates' folder (see Fig.6.30).

Switching to the 'Logic View' (click on the vertical tab on the left of the drawing area) is a particularly useful way to analyse any logic

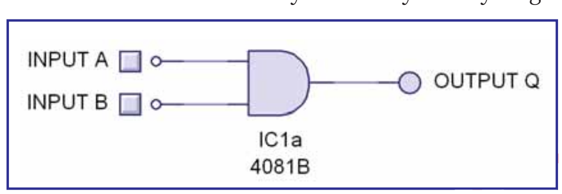


Fig.6.30. A simple arrangement to test an AND gate

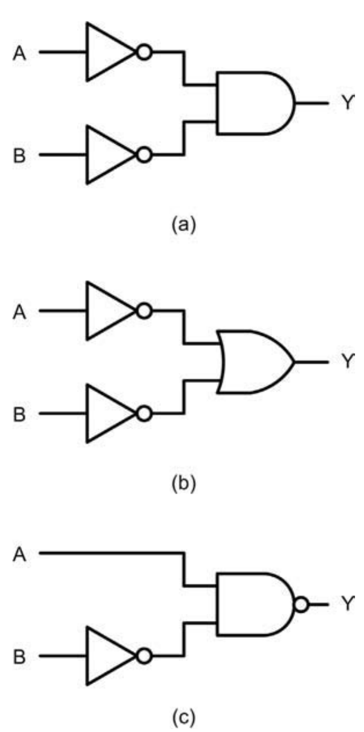


Fig.6.27. See Question 4

Build – The Circuit Wizard way

circuit. This view uses both colour coding as well as 1s and 0s at the inputs/outputs of each pin to show the logic state. This can really help you see what's going on around the circuit.

One important thing to note about the logic indicators and the 'Logic Level' view is that the logic high state is indicated by red, and the logic low by green. This might seem a little counter-intuitive to some people – the author included!

Give it a try

Experiment with some of the basic gates; AND, OR, NAND, XOR and NOT. Draw up a truth table for each gate and check that this matches what you've seen in ***Learn***.

Alternatively, we've developed an interactive logic gate worksheet (see Fig.6.31). This can be downloaded from the *Teach-In 2011* website; **www.tooley.co.uk/teach-in** – follow the link to Circuit Wizard downloads. Print out the worksheet and complete the truth tables by simulating them on screen.

Logic circuits usually contain a number of different gates and can get very complicated. Designers can spend a long time trying to figure out the simplest arrangement of gates to perform the logical function that's required.

However, with the widespread use and availability of microprocessors, complex combinational logic circuits are becoming a thing of the past. Have a go at entering and testing the logic circuit shown in Fig.6.32, and produce a truth table. Could the function of this circuit have been reproduced with fewer gates?

If you think about actually producing the circuit above you would need three logic ICs and two of the ICs would only have one gate used in them. Obviously, this is a pretty inefficient way to do things. Fortunately, logic designers came up with a great idea; what if we could use just a single gate and wire them in such a way to act like the other gates? In this way, you would only need to buy one type of IC.

It turns out that the NAND gate is the ideal candidate for this as you can produce all of the other gates using them – we call them 'NAND equivalents'. Fig.6.33 shows the NAND equivalent for an AND gate. Enter the circuit in to Circuit Wizard and verify that the combination acts just like an AND gate. In this case, the first gate is a straight forward NAND and the second gate acts as a NOT gate. Hence, the result is 'NOT NAND' or AND.

Why not see if you can figure out the NAND equivalents for the other gates. You can also download our NAND Gate Equivalent simulator (Fig.6.34) from the *Teach-In* website, which includes a number of other equivalents for you to explore.

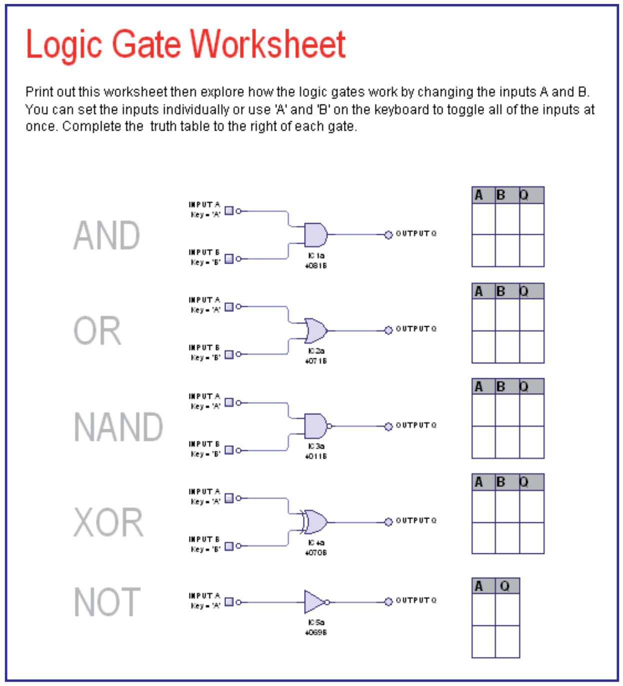


Fig.6.31. A view of our logic gate worksheet, which can be downloaded from: **www.tooley.co.uk/teach-in**

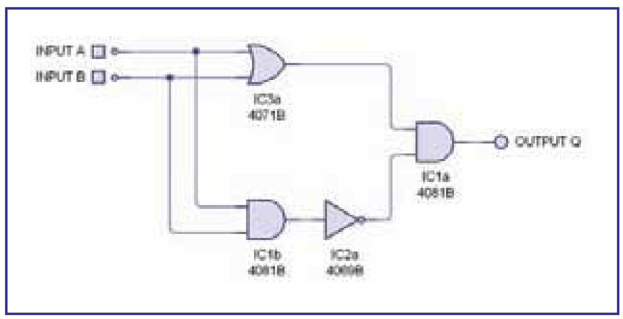


Fig.6.32. A combinational logic circuit

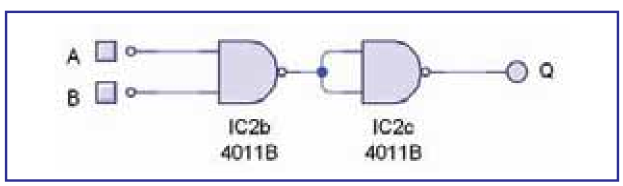


Fig.6.33. An AND gate made using NAND gates (in other words, a 'NAND equivalent' of an AND gate

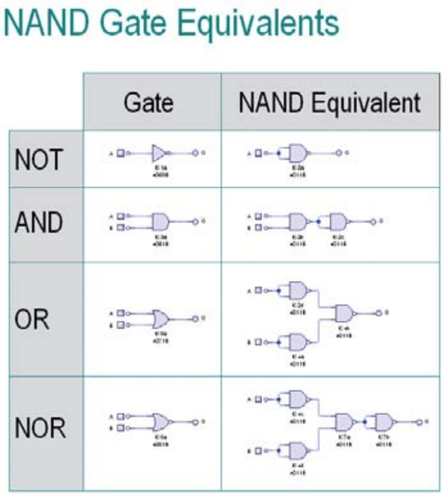


Fig.6.33. Download our NAND gate equivalent simulator from: **www.tooley.co.uk/teach-in**

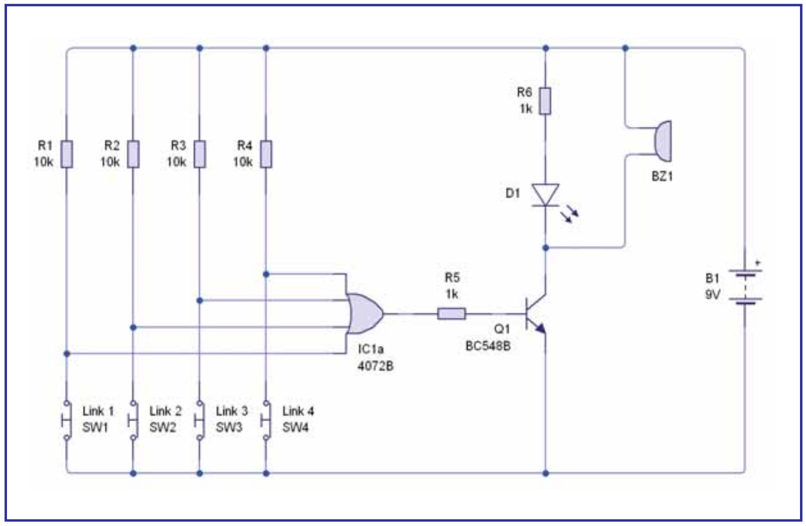


Fig.6.35. Intruder alarm circuit. When one of the 'links' is broken, the alarm sounds

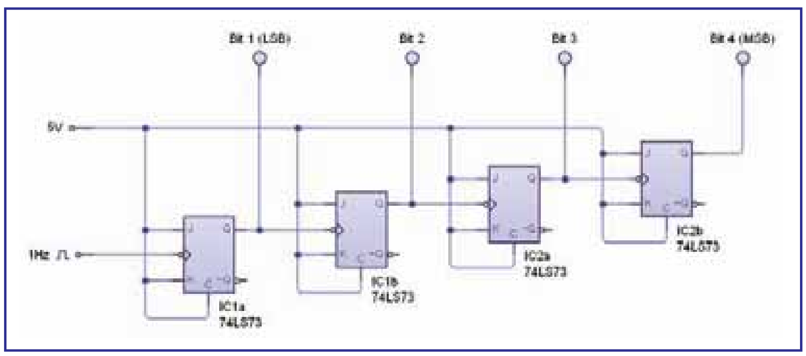


Fig.6.36. Four-bit ripple counter using J-K bistables

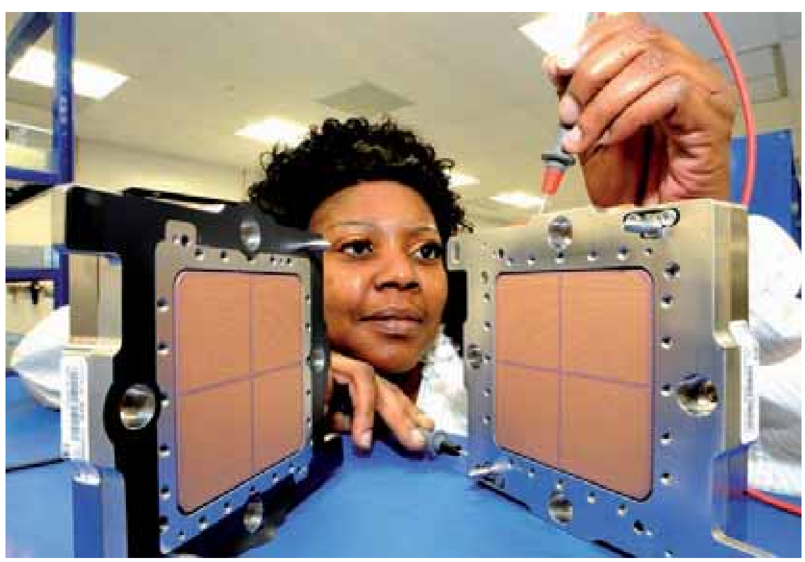
Intruder alarm

Now we'll look at a real-life application of a simple logic circuit. Fig.6.35 shows an intruder alarm circuit. When any one of the links (simulated by push-to-break buttons) is broken, the alarm is activated. Enter the circuit and try it out for yourself! Advanced readers might like to see if they can adapt the circuit to latch the alarm on once a link has been broken.

Ripple counter

Another area of logic design is sometimes described as sequential logic. Often this involves counting and/or timing. Fig.6.36 shows what is commonly known as a ripple counter or cascade counter. It produces a binary count using a series of J-K bistables or 'flip-flops'.

Enter the circuit and look closely at its operation. The 'Logic View' is excellent for this kind of circuit, and you should be able to see how the logic high 'ripples' along the flip-flops in order to generate a four-bit binary counting sequence.



The world's fastest microprocessor resulted from an investment of $1.5 billion, and operates at a speed of 5.2GHz (courtesy of International Business Machines Corp.)

Build – The Circuit Wizard way

Decade counter

A binary count could be really useful for lots of applications. Apart from possibly a few computer nerds, not all that many people can easily read a binary number!

Therefore, if we need to display a number to a consumer we need to convert this to a displayable number. This can be easily achieved with a 74LS47 seven-segment display decoder, a driver chip and a seven-segment LED display (common anode).

The chip decodes the four-bit lines of the binary count and outputs a number on the seven-segment LED display by turning on/off the appropriate lines. Amend your ripple counter circuit as shown in Fig.6.37. The NAND gate is used to reset the flip-flops when the count reaches 9, the highest single-digit number that can be displayed.

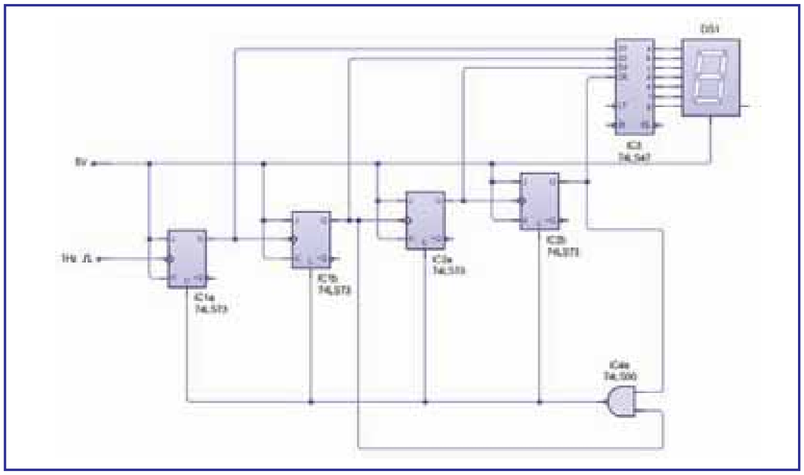


Fig.6.37. A decade (ie, 0-9) counter circuit using J-K bistables and a seven-segment display

Investigate

A block schematic diagram of a logic system used in a large aircraft is shown in Fig.6.38.

The system is designed to alert the flight crew by generating visible and audible warnings that one or more of the aircraft's undercarriage doors remain open when the aircraft is in normal flight.

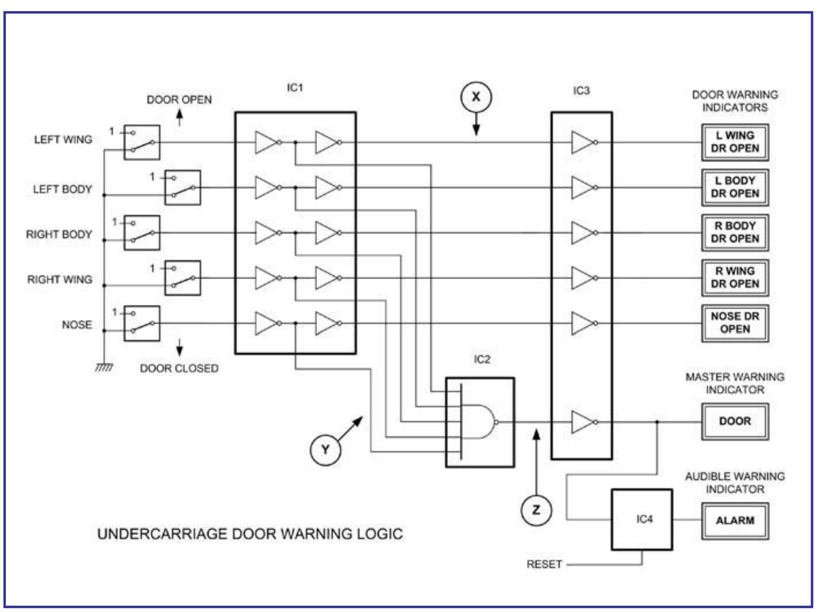


Fig.6.38. A block schematic of a logic system used in an aircraft

The five door switches provide logic 1 signals when the respective door is open and logic 0 when closed. All of the warning indicators are 'active low' and require a logic 0 to produce a visible or audible output.

Study the circuit carefully and then see if you can answer each of the following questions:

1. What logic level appears at points X, Y and Z with all of the doors closed?
2. What logic level appears at points X, Y and Z with the left wing door open and all other doors closed?
3. What logic level appears at points X, Y and Z with the nose door open and all other doors closed?
4. When any one or more of the doors opens, the audible warning

Answers to Check questions

6.1. (a) Three input OR gate
(b) Two input NAND gate
(c) Inverter or NOT gate
(d) D-type bistable (or D-type flip-flop)

2. See Fig. 6.40

3. See Fig. 6.41

4. (a) /A • /B (b) /A + /B
(c) /(A •/B)

5. See Fig. 6.42

A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

Fig.6.40. Answer to Question 2

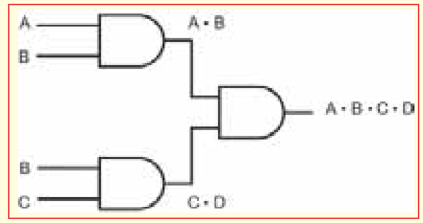


Fig.6.41. Answer to Question 3

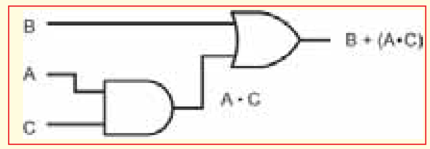


Fig.6.42. Answer to Question 5

should sound and remain operating until the flight crew cancels the alarm by means of the RESET button. What device should be used for IC4 and show how should it be connected?

Amaze

The time that it takes for a digital signal to travel from the input(s) of a logic gate to produce a change in the output is usually extremely small and measured in microseconds (μs), nanoseconds (ns), or picoseconds (ps). This time (often referred to as *propagation delay*) has a major impact in determining the maximum speed at which a particular logic circuit will operate.

Standard logic gates will happily operate at switching speeds of up to about fifty million operations per second, but even this is insufficient for use in high-speed applications such as the latest generation of microprocessors, which need clock rates that are very much higher than this.

Fig.6.39. IBM's new zEnterprise System mainframe (courtesy of International Business Machines Corporation)

The highest clock speed microprocessor currently sold commercially is found inside IBM's zEnterprise 196 mainframe computer. This device was introduced in July 2010, and its cores run continuously at a speed of 5.2GHz or 5,200,000,000 times a second.

Now that may sound fast, but future technology based on superconducting logic promises to offer speeds that are predicted to be around 100 times faster than this. So, as the old saying goes, 'you ain't seen nothing yet!'

Next month!

In next month's *Teach-In* we shall be looking at timers and pulse generators.

Circuit Surgery

Regular Clinic

by Ian Bell

Collector-base feedback/bias

EPE forum contributor ***Lost*** posted the following questions about collector-base feedback for a single-transistor amplifier.

Consider a capacitor-coupled NPN transistor amplifier with collector-base bias. Assume that the reactance of the capacitor is negligible at signal frequencies.

What type of feedback is involved – series-voltage, series-current, shunt-voltage or shunt-current? What is the feedback equation for this stage?

The circuit for a feedback amplifier of this type is shown in Fig.1. In the discussion which ensued, concerning apparent mismatch between textbook feedback theory on input/output resistance and the simulation of the circuit, Lost added:

Neither does it obey the standard negative feedback equation. That's why I asked if anyone knows what equation this 'simple' circuit follows.

It later became apparent that he may have been analysing a circuit without R_{in} (the circuit in Fig.2), which ***Alec_t*** correctly pointed out does not have any feedback.

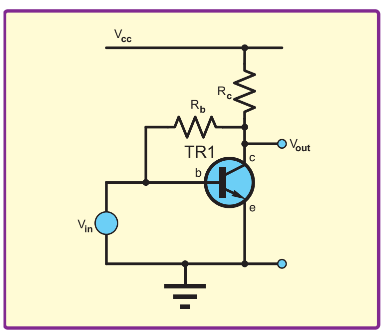


Fig.2. An NPN transistor amplifier with collector-base bias, but no input resistor

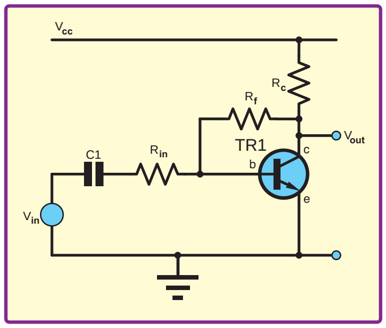


Fig.1. An NPN transistor amplifier with collector-base bias/feedback

Feedback basics

This month, we will look at the basics of feedback theory, which will allow us to answer Lost's first question about the type of feedback involved. Next month, we will look at analysing feedback in circuits in more detail.

An abstract diagram of an amplifier with feedback is shown in Fig.3 – the signals, labelled S, could be either voltages or currents. The amplifier on its own has a gain of $A = S_o/S_{ai}$, known as the **open-loop gain**. The whole circuit (amplifier with feedback) has a gain of $A_{CL} = S_o/S_{in}$, known as the **closed-loop gain**.

The feedback network produces a feedback signal, S_f, which is a fixed proportion, β, of the output signal. β is known as the **feedback factor**. As we go round the whole feedback loop signal, S_{ai} is first multiplied by the amplifier gain, then by the feedback factor and then –1 by the mixer, so the feedback is $-\beta AS_{ai}$. The value $-\beta A$ is known as the **loop gain**.

Referring to Fig.2, we can calculate the closed loop gain in terms of the open loop gain and feedback factor. The feedback signal is the output multiplied by the feedback fraction:

$$S_f = \beta S_o$$

Subtracting the feedback signal from the circuit input gives the amplifier input:

$$S_{ai} = S_{in} - \beta S_o$$

The amplifier (and circuit) output is the amplifier input multiplied by the amplifier gain:

$$S_o = A(S_{in} - \beta S_o)$$

$$S_o = AS_{in} - \beta AS_o$$

Collecting all the output terms together gives us:

$$S_o + \beta AS_o = AS_{in}$$

$$(1 + \beta A)S_o = AS_{in}$$

and rearranging to find the closed-loop gain, we get:

$$A_{CL} = \frac{S_o}{S_{in}} = \frac{A}{(1+\beta A)}$$

Sensitivity

This is the fundamental equation for feedback circuits. A very important result, which follows from this equation is that negative feedback tends to make the gain

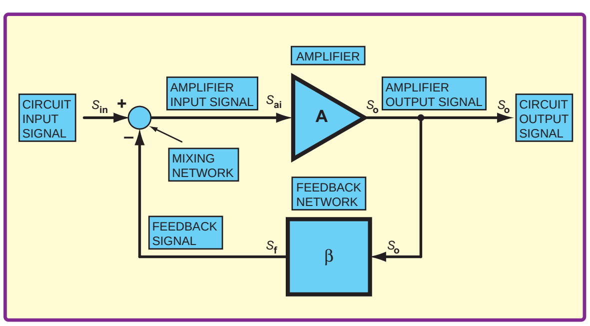


Fig.3. Structure of a feedback amplifier circuit

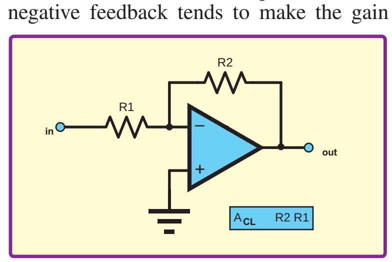


Fig.4 (above right). Op amp inverting amplifier

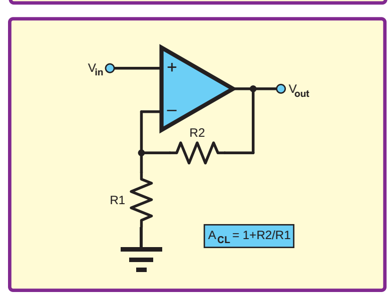


Fig.5 (right). Op amp non-inverting amplifier

Both bipolar transistors and FETs are inherently current output devices (collector or drain current); however, we can readily obtain a voltage output by passing this current through a load resistor (as shown in Fig.1 and Fig.2). Thus, a bipolar transistor with an output resistor can be regarded as either a voltage or transresistance amplifier, and a FET with an output resistor is a voltage amplifier.

Operation amplifiers (op amps) are inherently voltage amplifiers. Operational transconductance amplifiers (OTAs) are also available as ICs (eg, LM13700).

Feedback network

Like the amplifier, the feedback network can have either voltage or current input or output. This leads to four feedback configurations, corresponding to the four amplifier types in Table 1. The input type of the feedback network corresponds to the amplifier output, and the output type of the feedback network corresponds to the amplifier input. The four types of feedback configuration are shown in Fig.6 to Fig.9.

For voltage output amplifiers, the feedback network is connected across the amplifier output, as shown in Fig.6 and Fig.8. This voltage-sampled feedback is also referred to as *parallel* feedback, because the feedback network is in parallel with the load.

For current output amplifiers, the feedback network samples the output in series with the load – the output current flows through both the load and feedback network, as shown in Fig.7 and Fig.9. Current-sampled feedback is also referred to as *series* feedback.

The mixer may subtract either a voltage or a current from the source signal before is it applied to the amplifier input. Voltage subtraction is easily provided by series connection of the voltage output of the feedback network with the source voltage. This is shown in Fig.6 and Fig.7. In both circuits, Kirchhoff's voltage law shows us that $v_{ai} = v_{in} - v_f$. This type of mixing is referred to as *voltage-input* or *series-input* feedback.

In Fig.8 and Fig.9, the feedback network subtracts a current from the source output before it reaches the amplifier. The feedback network *shunts* the source, diverting some of its current. Kirchhoff's current law shows us that $i_{ai} = i_{in} - i_f$ for both of these circuits. This type of mixing is referred to as *current-input* or *shunt-input* feedback.

The overall names of the four feedback configurations combine the sampling and mixing descriptions, with the mixing type (usually) named first. For example, Fig.6, which combines series-mixing with voltage-sampling is called series-voltage feedback. There are variations on these names, for example Fig.6 may be called voltage-voltage, series-shunt, series-parallel, and possibly other names. The name variations can be confusing.

Unilateral assumption

There is an important assumption underlying the idealised feedback circuits depicted in Fig.3 and Fig.6 to Fig.9. This assumption is that both the amplifier and feedback block are *unilateral*, that is they only transmit, or transfer, signals in one direction. This is indicated by the arrows in the amplifier and feedback blocks.

We assume that changes of the output voltage or current of the amplifier have no influence on the voltage or current at its input (eg, by changing the input impedance). Similarly, we assume that the voltage and current at the output of the feedback block have no influence on the block's input.

These assumptions are generally good for op amp-based circuits, but less so for transistor circuits. Like the effect of relatively low transistor gain mentioned earlier, this makes idealised analysis of transistor circuits less accurate than with op amps.

The op amp non-inverting amplifier (Fig.5) is perhaps one of the more straightforward real circuits to interpret in terms of feedback configurations. The two resistors R1 and R2 form a potential divider, delivering a proportion of the output voltage to the inverting terminal of the amplifier. This effectively subtracts the potential divider voltage from the input voltage – so we have a case of series-voltage feedback.

Using the well known potential divider equation we get:

$$v_f = \frac{R_2}{(R_1 + R_2)} v_o$$

So β = R2/(R1+R2). Using $A_{CL} = 1/\beta$ gives us:

$$A_{CL} = \frac{(R_1 + R_2)}{R_2} = 1 + \frac{R_1}{R_2}$$

the well-known gain expression for this circuit.

Summary

To answer one of Lost's questions, the circuit in Fig.1 is an example of shunt-voltage feedback. The transistor acts as a transresistance amplifier, with R_{in} converting the input voltage depicted in Fig.1 into the input current (ignoring the capacitor).

The feedback resistor causes a feedback current, dependent on the output voltage, to flow in opposition to the input current, as indicated on Fig.8. The inverting op amp amplifier (Fig.4) is a very similar circuit configuration, which can also be interpreted as using shunt-voltage feedback.

The circuit in Fig.2 does not have any feedback, assuming V_{in} is an ideal voltage source. If the voltage source has internal resistance, the circuit reverts to that in Fig.1, with the source resistance performing the role of R_{in}. With an ideal source, the feedback resistor has no influence over the input to the transistor. The transistor's base-emitter voltage and hence base current is set wholly by the voltage source. In this circuit, R_b acts only to load the output.

This month, we have partly answered Lost's question about the nature of feedback in the circuit in Fig.1. We have mainly considered the fundamental theory of the feedback amplifier, which has allowed us to answer the question about which type of feedback is involved. Next month, we will look at the actual transistor circuit in more detail.

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

PIC Internet Computer – Part 5

THE soldering iron stays firmly in the cupboard this month as we take a look at the 'build environment' for our main application, based around the free Microchip compiler. We are going to zip through the process of installing all the software tools, so you might find that some of these steps don't apply to you.

You should note, however, that some of the source code that we use from Microchip is pretty recent, and may not be compatible with older installations of MPLAB or the PIC24 C compiler. The simplest approach is to install the missing software when we get to it, and only go back to the beginning if you have problems.

For a clean installation, we will be downloading three products from Microchip: The MPLAB integrated development environment; C30, the PIC24 C compiler; and the 'Application Libraries' – a collection of software libraries for the PIC processors, which contains the two libraries we are interested in – the SD Media card file system library, and the TCP/IP stack software.

MPLAB and C30 do need to be fairly recent – if you haven't installed an update in the last six months, you probably need to follow all these instructions. In total, we will be downloading approximately 250MB of data – so if you do not have broadband, you need to find a friend who does. And give them a blank CD!

The three downloads are the following:

MPLAB v8.63 (100MB) http://bit.ly/i9gQhZ

C30 Compiler (47MB) http://bit.ly/f55dlK (choose the Standard-Eval version)

Application libraries (107MB) http://bit.ly/fKeyxk

Note that to download the C Compiler you will need to register an account, and login. This process does not demand an excessive amount of information, and is quite quick.

Installation

MPLAB – extract the zip file to a temporary sub-directory on the desktop, then run **setup.exe**. Click through the usual licence agreements to start the installation process. Click 'No' to installing the HI-TECH C installer, and on completion allow the PC to reboot.

Next, install the C30 compiler. When prompted for the installation type, select 'Evaluation Compiler' (unless you are one of the lucky ones who could afford to buy the standard licence. If that's the case, enter your serial number here.)

Finally, unzip the application libraries zip file, and run the executable. Accept all the defaults (this installs all the application libraries; you can remove unused features at a later date, if you wish.)

Now let's test the software installation by creating a very simple project. Double-click on the MPLAB IDE icon on your desktop, and select **Project** then **Project Wizard**. Click **Next** and select our processor from the drop down list – PIC24HJ128GP202. Then click **Next**. A dialog similar to Fig.1 should appear.

For every item in the 'Toolsuite Contents' list, a co-responding entry should be visible in the 'Location' field. This is set up automatically if you followed the previous instalation instructions. However, it is possible that the links are not made – in this case, manually locate each Toolsuite item by clicking on the Browse button and selecting the required file. These are all found in the 'bin' sub-directory, as shown in the Location field.

Once all tools have been located, click **Next**. You are now prompted to enter the name for the project. Click the **Browse** button and navigate to your desktop, then enter a name like 'quick-test'. Click **Save** followed by **Next**. You now have the chance to add some existing source files to the project; just click **Next** here, then **Finish**.

You are now presented with an empty project within MPLAB. From the main menu click **File,** then **Add New File to Project**. Navigate to your desktop, then type in the filename **main.c** and click **Save**. In the new editor window that pops up in the following code:

```
#include <stdlib.h>
#include <stdio.h>
int main ( void )
{
   puts("Hello!");

   return 0;
}
```

That's a very simple program that will just prove our compiler is working – we will not be downloading it to any hardware, and so we can skip the task of setting up the processor configuration bits (the normal painful part of any new PIC project.)

The heap

We do need to specify one extra parameter, a small amount of RAM memory for the 'heap' – the pool of memory where C programs can dynamically request and return storage from. The heap is used by the **malloc** and **free** functions, which are used extensively by the TCP/IP stack software. More on that later. For now, we need only specify a small amount of storage for our test application. From the main menu selection **Project** followed by **Build Options..** and then **Project**. Click on the 'MPLAB LINK30' tab and in the 'Heap size:' field enter 128. Click **OK** to save the settings.

So let's find out if everything is working – from the main menu select **Project** followed by **Build All**.

If all goes well you should be greeted with 'BUILD SUCCEEDED' in the output dialogue.

Scrolling up through the Output dialogue box will reveal details about the memory utilisation, both Flash and RAM, for our very simple program. Don't be concerned by the rather excessive memory use (15% of RAM, 1% of Flash) as these are default memory regions set aside for your data, as and when you use it.

The C programming language is actually very efficient, but can generate a small overhead that is only obvious with tiny programs like these. For larger projects, the overhead actually helps out. So there is no need to curse the C30 compiler for turning what looks like a thirty byte program into over two thousand!

Finally, close the project by selecting **Project** from the main menu, followed by **Close**, and then exit MPLAB.

On the desktop you should see that seven files have been created; five with our project name, **main.c** and **main.o**. When you want to open a project in MPLAB you should double-click on the file with the **.mcp** extension. This file contains all the information about your

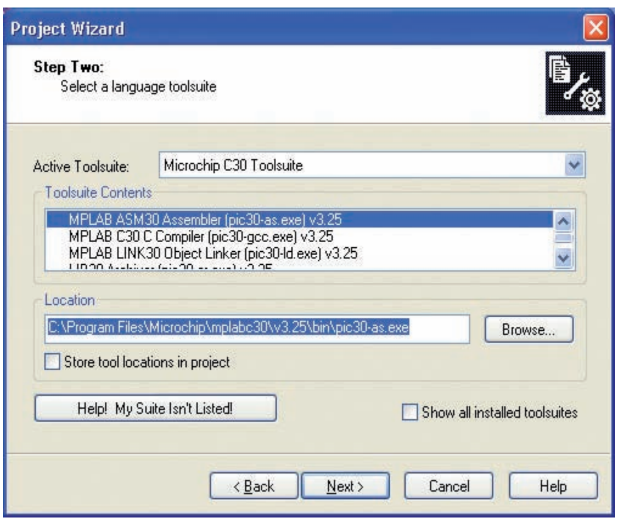


Fig.1 MPLAB tool configuration

project files and configuration. MPLAB will then know how to organise all the files.

You can delete these seven files now, and we can move onto the more complicated issue – the Application Library.

Application library

The two major software components we require for this project come for free from Microchip – but at a price of another kind. The TCP/IP stack and memory card file system are wrapped up in an 'Application Library' suite, with many other useful (but to us irrelevant) source code libraries totaling 6000 files and 395MB of file space. It's a hugely complex collection of software, and takes a lot of patience to pick through to find the relevant parts. The files are located by default in 'C:\Microchip Solutions v2010-10-19'.

We will start with the simple software library, the SD Media card file system. The core library files are in the 'Microchip\MDD File System' sub-directory, with an example project located in 'MDD File System-SD Card'. Opening up the PIC24 MPLAB project file MDDFS-SD-PIC24.mcp reveals a reassuringly simple collection of files, as shown in Fig. 2. Only two source code files (and several header files) are referenced, so integrating this into our own project is not going to be too difficult.

Fig.2 also highlights a standard feature of the application libraries – one header file (**FSConfig.h** in this case) is used to specify what features of the library are required in our specific application, and the file **hardwareProfile.h** that is used to specify what pins on our processor are used to connect the physical device to our chip.

Neither of these files are well documented; you have to work out what they do by careful inspection of the source, and a certain amount of 'suck it and see'. Fortunately, we've done this for you, so we can concentrate on the interesting part – actually using the functions provided.

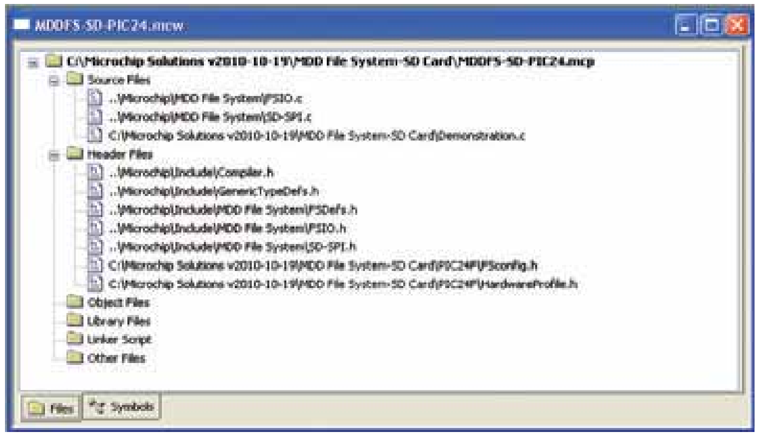


Fig. 2 Media card source files

TCP/IP stack

A good and relatively simple example application is provided to demonstrate the features of the TCP/IP stack, and this can be found in the directory 'TCPIP MDD Demo App'. This time, however, the source files used extend to over forty rather than just two! To be fair, the stack code is *very* extensive, and even provides the ability to send emails. We will not have to edit any of these files, however. We just need to choose what features we wish to use through the header file **TCPIPConfig.h**.

Realising that choosing the features required was going to be complicated, Microchip have created an application to create that file for you. Called **TCPIPConfig.exe**, it can be found in the 'Utilities' sub-directory in the Stack source area.

Over the course of the next four weeks, we will set up the initial file system and stack configuration files, and prepare the final hardware design – adding in the MicroSD Media card interface and the Ethernet interface using the ENC28J60 IC – both circuits have been used before in *PIC n' Mix*. From there, we can start to glue the parts together quickly and demonstrate how the Microchip tools, once configured, provide a huge amount of easy-to-use functionality.

By Robert Penfold

INTERFACE

A simple analogue optical interface

THE previous *Interface* article covered a simple method of providing digital outputs using the computer's monitor and an optical detector circuit. Using this method, it is possible to provide an accurate 8-bit analogue output using eight optical detector circuits to drive a conventional digital-to-analogue converter. This would be quite involved though, and would be doing things the hard way if a high degree of precision was required.

For something like a computer controlled power supply, it would be necessary to have a high degree of precision, so that the output voltages could be set with good accuracy. On the other hand, accuracy is often of little importance for an application such as a motor speed or light controller. In simple applications of this type it is merely necessary to have available a good range of speeds, light levels, or whatever.

Light work of it

On the face of it, there should be no problem in providing a simple analogue output using a single optical detector circuit. Under software control the light output from an area of the screen can be varied instead of simply being switched between black and white, and a suitable detector circuit can provide an output potential that is roughly proportional to the screen brightness. However, there are too many potential flaws in the system for the output voltage to be anything more than roughly proportional to the control values used.

The optical detector circuit could be designed to have a high degree of linearity, but this is pointless unless a similarly high degree of linearity could be obtained between the control values and the screen brightness. In practice, it is likely that there would be a lack of precision in this respect. Practical tests suggest that there are significant differences in the results obtained from various monitors, and that the way a particular monitor is set up can also produce massive variations.

The ambient light level does not usually have a large effect on the results obtained, since it is not too difficult to shield the photo detector. However, its influence would probably be sufficient to prevent a very high degree of accuracy from being obtained. Anyway, no attempt at precision results will be made in the design featured here, and high accuracy using this method is probably not a practical proposition. This interface is only intended to act as the *basis* of a system where relatively 'rough and ready' results will suffice.

As was the case with the circuits featured in the previous *Interface* article, this one is only designed for use with LCD monitors, and it will not work properly with a CRT type. This is due to the way a CRT monitor produces the picture.

Practical circuit

The circuit diagram for a simple analogue optical interface is shown in Fig.1. TR1 is a BPV11 phototransistor, and it provides the upper arm of a potential divider circuit across the supply rails. The other arm of the potential divider is provided by resistor R1, and the voltage developed across this resistor is proportional to the leakage current through TR1.

Unlike some phototransistors, the BPV11 does have a base leadout wire, but in this circuit it is left unconnected. It is the collector-to-emitter leakage current that is of importance here.

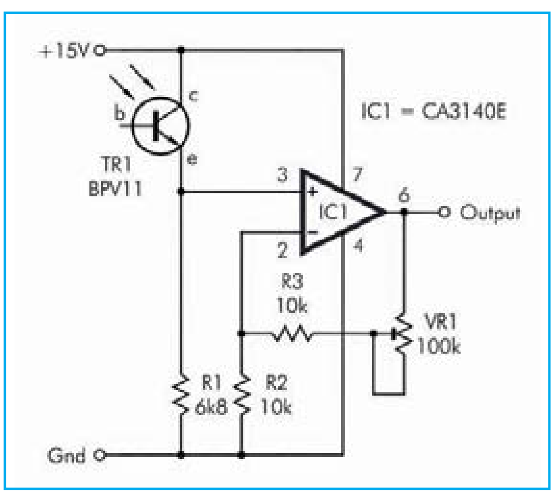


Fig.1. The circuit diagram for the optical analogue interface. 8-bit resolution is easily achieved, but not 8-bit accuracy

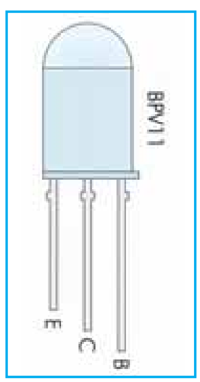


Fig.2. Leadout details for the BPV11 phototransistor. This device has a base lead, but in the circuits feature here it is left unconnected

In total darkness, TR1 has the very low levels of leakage current associated with normal silicon transistors, and the potential developed across R1 is then negligible. As the light level is increased, the leakage current through TR1 rises, and the voltage developed across R1 also rises.

The range of voltages produced across R1 in the present application will depend on factors such as the brightness and contrast of the monitor, the precise characteristics of the particular example used for TR1, and how well TR1 is shield from ambient light. However, it will typically vary from a few millivolts to just under two volts.

IC1 is a simple operational amplifier (op amp) non-inverting circuit that acts as a buffer stage, but it also provides a certain amount of voltage amplification. Preset VR1 (wired as a variable resistor) enables the voltage gain of the amplifier to be varied from two to about 12 times. This enables the maximum output voltage to be varied from around 3V to a maximum of about 12.5V. The maximum output potential is imposed by the 15V supply voltage and not by the voltage gain of IC1.

Components

The CA3140E operational amplifier specified for IC1 is a type that will operate in single supply DC circuits. Most other op amps will not work properly in this circuit unless a conventional dual balanced supply is used. The CA3140E is a MOS device and the standard anti-static handling precautions should therefore be taken when dealing with this device.

It is important that the device used for TR1 is the standard version of the BPV11. In common with most phototransistors, the standard version has peak sensitivity in the near infra-red part of the spectrum, at about 850nm. It has good sensitivity in the red and green parts of the visible light spectrum, but the sensitivity falls off significantly towards the blue/violet end of the spectrum. This is again common to most phototransistors and diodes.

In order to obtain the greatest contrast, and therefore the greatest voltage range across R1, it is advisable to control the circuit from an on-screen object that varies from black to white, rather than using one particular colour. The circuit is unlikely to work well enough using a blue or violet control object.

There is another version of the BPV11, which is the BPV11F. This seems to be essentially the same component as the standard BPV11, but its sensitivity peaks at 950nm, and it has a built-in infrared filter.

As it is completely insensitive to the visible light part of the spectrum it is not suitable for use in this circuit.

The standard BPV11 has a clear plastic case, as used for many 5mm diameter light emitting diodes. The BPV11F has the same type of case, but it is tinted a dark grey colour by the built-in infrared filtering, making it easily distinguished from the standard device.

The device's three leadout wires are easily identified as they are of different lengths (see Fig.2). Once the leadout wires have been trimmed it is still possible to identify them, because the case has the usual LED-style 'flat' next to the emitter lead. The three leads emerge from the device in a line, but the collector lead is preformed so that the leads are effectively in a triangular configuration.

The built-in lens of the BPV11 gives it a ±15 degree angle of view, which helps to avoid problems with the ambient light level affecting results. However, as far as reasonably possible it should still be shielded from ambient light. It should be placed as close as possible to the relevant part of the monitor's screen, but it should not be allowed to come into contact with the screen. This is to prevent possible damage to the screen.

Signal processing

In a practical application, it will usually be necessary to have suitable signal conditioning circuits to process the output of the basic circuit of Fig.1, so that the required output voltage range and maximum load current can be accommodated. One obvious shortcoming is that the minimum output voltage of the basic analogue interface is not zero. The minimum voltage obtained depends on the closed-loop voltage gain of IC1 and the lowest light level that can be achieved; it is typically around 20mV to 30mV.

This will not necessarily be a problem, and in a DC motor control or lighting application for example, an 'off' state would effectively be reached well before the on-screen control object was reduced to its black setting. If necessary there are various ways of overcoming the slight offset, such as using a level shifting circuit.

Another option is to use an output buffer amplifier such as the one shown in the circuit diagram of Fig.3, which produces a voltage drop that will more than counter the offset voltage. This circuit can handle output currents of up to about 2A, but output transistor TR3 must be fitted to a large heatsink to prevent it from overheating.

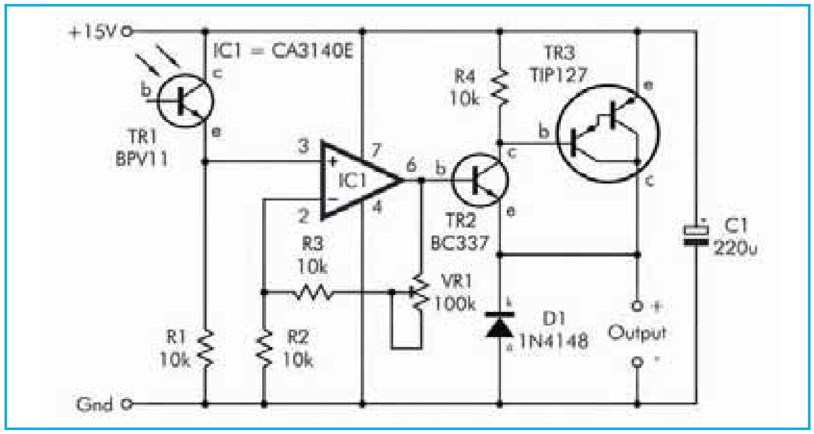


Fig.3. Adding a buffer stage to the original circuit removes the offset voltage at the output and enables the unit to handle output currents of up to about 2A. Output transistor TR3 MUST be fitted with a large heatsink

A third option is to use a simple optical interface to provide on/off switching at the output of the circuit. This can be handled by the circuit of Fig.4, which is essentially the same as the relay interface featured in the previous *Interface* article. A circuit of this type can also be used for other switching purposes, such as providing direction control for a DC motor.

Software

A very simple control program should suffice, and the example program provided in Listing 1 was written using Visual BASIC Express 2010/2011. This has two buttons that control the background colour of a label component (Label1). The label contains no text, and it is only its colour that is of importance here. It can be set as white by operating Button1, or black by operating Button2. These buttons are notionally used to provide forward/reverse switching in this example, but could be used for on/off switching, or any other simple switching task using the circuit of Fig.4.

The variable output is handled by a horizontal scrollbar and another label component (Label2). The scrollbar must have its maximum and minimum values set to 255 and 0 respectively, as it is only integer values in this range that can be used to control the colour of the label component. The colour is controlled by using the value from the scrollbar as the RGB values for the label's background colour.

A Dim statement is used to define a new colour, which in this example is called OutputVal. This colour is then used as the BackColor value for Label2. Since the red, green, and blue values are all the same, the label is black with the scrollbar set at minimum, and white when it is set to its maximum value. In between these two extremes there are 254 shades of grey. This effectively gives 8-bit resolution, but as explained previously, this method will not give anything approaching normal 8-bit accuracy. The screen dump of Fig.5 shows the program in action.

Listing 1

```
Public Class Form1

 Private Sub Button2_Click(ByVal sender As System. Object, ByVal e As System. EventArgs) Handles Button2. Click
        Label1. BackColor = Color. Black
 End Sub

 Private Sub Button1_Click(ByVal sender As System. Object, ByVal e As System. EventArgs) Handles Button1. Click
        Label1. BackColor = Color. White
 End Sub

 Private Sub HScrollBar1_Scroll(ByVal sender As System. Object, ByVal e As System. Windows. Forms. ScrollEventArgs) Handles HScrollBar1. Scroll
        Dim OutputVal As Color = Color.FromArgb(HScrollBar1. Value,HScrollBar1. Value, HScrollBar1. Value)
        Label2. BackColor = OutputVal
   End Sub
 End Class
```

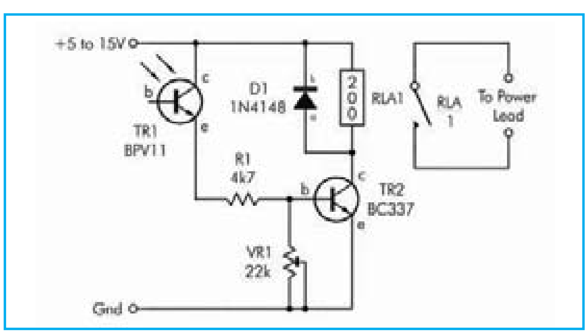


Fig.4. A simple optical interface that can be used to control a relay. The latter can be used to provide on/off switching and direction control.

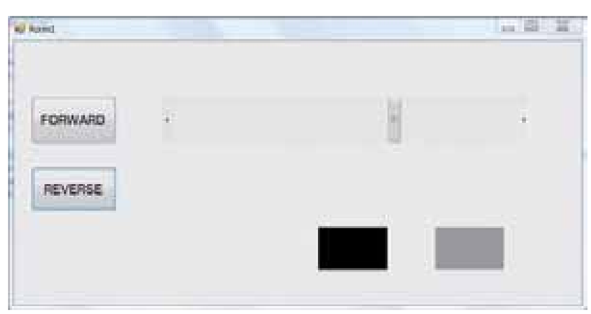


Fig.5. The example program in operation. The scrollbar provides 256 output levels and the two buttons control a relay

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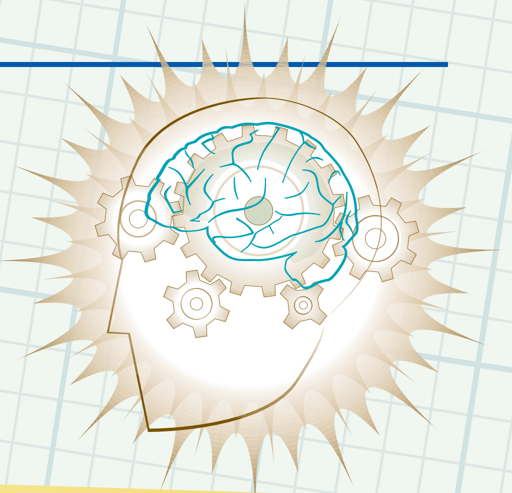
Our regular round-up of readers' own circuits



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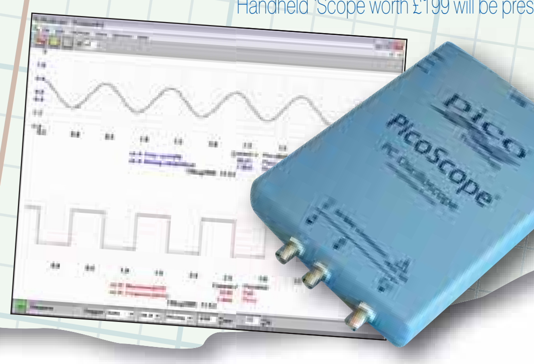

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Universal Remote Control Receiver – *In control*

MOST readers will have old IR (infrared) remote controls lying around the house, usually from those old TVs or DVD players that were dismantled or recycled years ago. Now you can find a use for those 'remotes' by using them to control the Universal Remote Control Receiver.

The circuit diagram shown in Fig.1 uses a PNA4602M IR detector (I used RS Components part number 199-630, but other suppliers may also stock this item) to receive an IR signal from the remote control. It's a neat device, which contains an IR receiver, amplifier and demodulator together in a single 3-pin package, and it's normally used in circuits where you want to decode an IR remote control signal.

How it works

The way the circuit (Fig.1) works is as follows. When there is no IR coded signal present, the output pin of IC1 remains high. This high signal is fed to the trigger input of the 555 timer (IC2), which being configured as a monostable timer, prevents the timer operating.

Whenever you briefly press any key on the old remote control its IR signal is received by IC1 and output pin 1 produces a train of fast moving high and low pulses, which mimic the IR signal code sent by the remote control. We are not interested in this code, but as soon as the signal switches low it triggers the monostable timer IC2 and its output pin 3 goes high for a short period of time, set by resistor R2 and capacitor C2.

The 555 timer (IC2) basically acts as a debounce circuit, and its output is fed into the clock pin (CLK) of the 4013B dual D-type flip-flop IC3. Only one half of the chip is used in this application, and it is configured as a bi-stable flip-flop.

An initial clock signal into IC3 causes its output pin 2 to go high, and it remains high until another IR signal is received. To switch the output off you simply press any button on the old remote control again and the above operation is repeated, but this time IC3's output is switched off and remains off until another signal is received. The output basically acts as a toggle switch.

The output pin in this circuit drives an LED to show the output status. However, the output could be easily interfaced to drive a transistor and relay to switch a higher load. The circuit could then be used to remotely switch equipment in your garage, shed or office.

Don't forget that you need to use the circuit in an area where IR remote controls are not normally present, because the circuit will operate with virtually any IR remote control. Capacitor C1, positioned across the output of the IR receiver (IC1), stops spurious triggering from artificial lighting, which can occur if this isn't in place.

Nick Dossis,
Middlewich, Cheshire

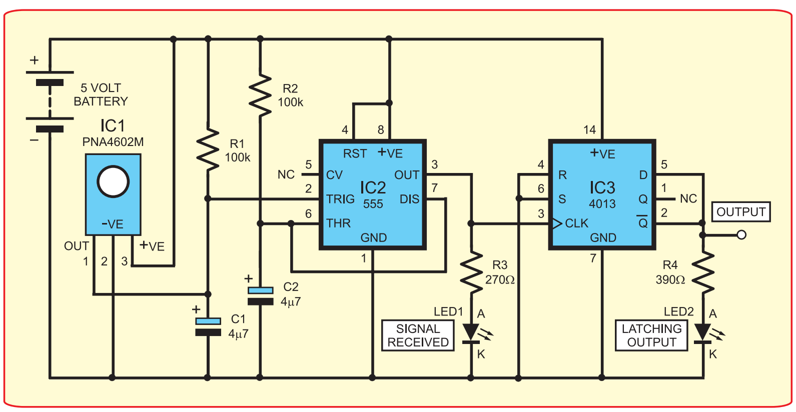

Fig.1. Circuit diagram for the Universal Remote Control Receiver

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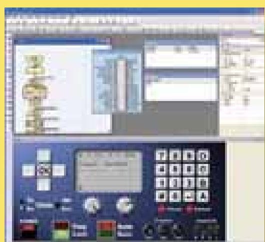
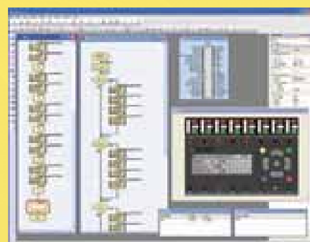
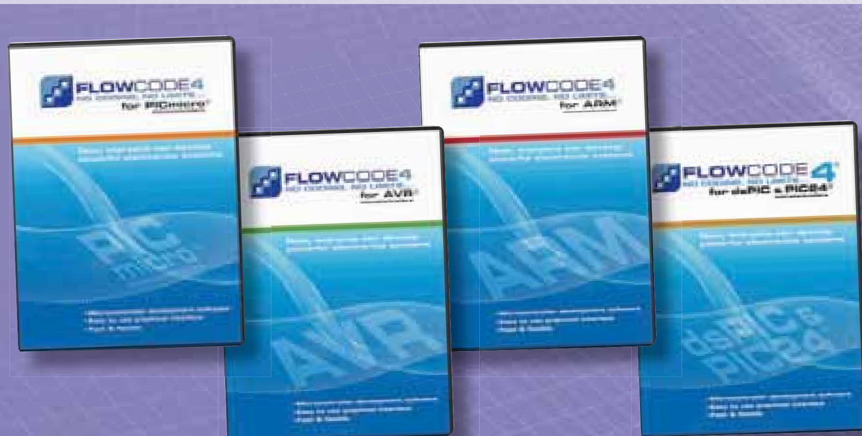


Design
Flowcode contains standard flow chart icons and electronic components that allow to you to create a virtual electronic system on screen. Drag icons and components onto the screen to create a program, then click on them to set properties and actions.



Simulate
Once your system is designed you can use Flowcode to simulate it in action. Design your system on screen, test the system's functionality by clicking on switches or altering sensor or input values, and see how your program reacts to the changes in the electronic system.

Download
When you are happy with your design click one button to send the program directly to your microcontroller based target. Targets include a wide range of microcontroller programmers, upstream E-blocks boards, the Formula Flowcode robot, the MIAC industrial controller, or your own system based on ECIO technology.



FlowKit
The FlowKit can be connected to hardware systems to provide a real time debug facility where it is possible to step through the Flowcode program on the PC and step through the program in the hardware at the same time. The FlowKit can be connected to your own hardware to provide In-Circuit Debug to provide your finished designs.

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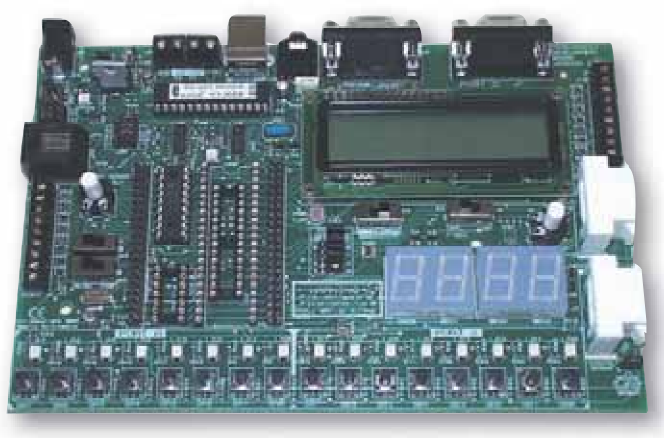

£161 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

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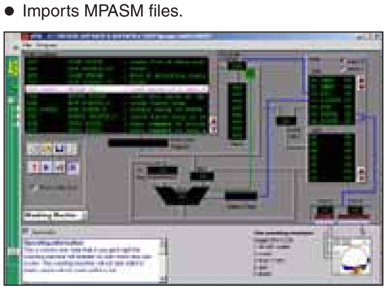

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The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

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Flowcode will run on XP or later operating systems

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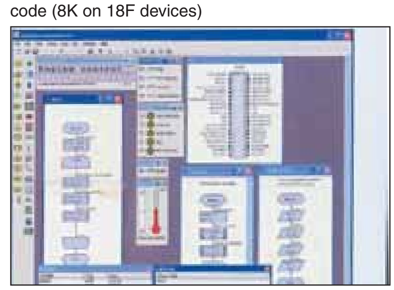
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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Net Work

Alan Winstanley

Last month, I mentioned problems that I'd experienced with my wireless network, as wireless devices such as my WiFi Pure Evoke radio and laptop PCs were prone to 'going blind' and falling off the network.

Over the years, I've tried three or four routers from well-know names, including Linksys, Belkin and Netgear: all of them failed in use. Often it was due to the power supply or a port going down, or WiFi compatibility problems. Last time, I'd installed a cheap and cheerful Tenda W300D, which has been flawless as far as wired 10/100Mb ethernet was concerned, but wireless performance became problematic to the point where I'd have to power the stubborn router down overnight before any wireless device would connect properly next day. I suspected problems with the router's DHCP function, which allocates IP addresses to each device. A DHCP firmware update saw no improvement.

Another bottleneck was building up on my system, though: the Tenda router has a typical 4 port 10/100Mbps switch, but my PCs each have gigabit Ethernet, as does my Ethernet-connected Netgear backup drive. As several major backups and data recoveries each took 20 hours or more, this finally prompted me to consider upgrading to something faster. One option would be to add a gigabit switch onto the existing router, but faced with a slightly temperamental Tenda, I opted to find a wireless router with a 4-port gigabit switch instead.

A cool billion

Some places to take some practical soundings include Amazon reviews, which highlight some off-putting feedback about some well-known brands, or the Whirlpool network forum in Australia at *http://tinyurl.com/levhap*. The dedicated site **www.broadbandbuyer.co.uk** is a well-regarded supplier of routers and network equipment, which also hosts a lively user forum. This is where the Billion BiPAC 7800N ADSL2+ Dual WAN router caught my attention. At £119 the Billion is costlier than an average 'home' router, but it's the only device in Billion's range classified as suitable for office and SoHo (small office/home office) use. Its feature list fitted the bill perfectly and a quick trip to **www.billion.uk.com/product/wireless/7800n.htm** confirmed that it had all the features I needed, and more. At the time of writing, the Billion is also stocked by Maplin (**www.maplin.co.uk**).

One issue I've raised in the past is ventilation: small home-type routers seem to get worryingly hot with constant use, and I even took to using a cheap fold-out USB-powered laptop cooling fan (from eBay, 99p) underneath the Tenda, which cooled it considerably. One plus-point is that the Billion 7800N is probably the best-ventilated router that I've come across; it has grilles all around, on top and underneath, underlining its always-on SoHo credentials.

I was soon unpacking the Billion router ready for installation and found that it had several tricks up its sleeve – it's a dual WAN device for use either as an ADSL router or a broadband router with cable or fibre, so it's instantly cable-ready for the future. If using ADSL, then the cable ethernet EWAN port doubles as a handy bonus fifth (10/100) port on the gigabit switch.

The Billion 7800N is a high performance router suitable for small-office/ home office users

After powering up, a row of green LEDs on the router confirmed that – at last! – gigabit Ethernet had arrived in my worklab. As soon as I opened my web browser, Billion's Easy Sign-On screen automatically launched – neat. It was then a simple case of entering the basic protocol details, username and password and the router immediately connected to my ADSL. (You will need those details from your host, so check that you have them beforehand.)

Getting started

The next port of call was the maker's website to fetch a firmware update for UK users, as recommended by forum users, and then the wireless network setup was tackled. Billion's software caters for beginners and advanced users and the novice would have no problems navigating around the 'Basic settings' screen. The main rule is to leave at their default settings anything that you're unsure about. The Billion router has plenty for expert users to configure (helped by an excellent, well-written manual) so I'll confine my comments to explaining some basic aspects and jargon for setting up typical small networks. Quite often, default settings are fine, but a tweak may be needed sometimes. Configurations could be saved as a file, so you can experiment with different setups.

Early considerations include DHCP (dynamic host configuration protocol); most users will probably want the router to allocate unique IP addresses to anything connecting to the network, and DHCP will probably be enabled by default in the router. The router's NAT (Network address translation) feature means in effect that individual network users can each access the Internet through the system's single IP address, so NAT should be enabled.

Next come the wireless settings; deep in the router, I chose 802.11b + g + n mode. Network interface cards (NICs) installed in older wireless-connected computers may not be compatible, and may need 'throttling back' to 802.11b (11Mbps) only. Or consider using 802.11n USB dongles, which are quite cheap. On one PC tucked away in a corner, I extended the wireless NIC's aerial onto the desk to help improve reception a little. Base-mounting WiFi aerials with cables can be had on eBay for just a few pounds.

Next choose an ESSID (extended service set identifier) – a human-readable name for your network. Then choose a wireless channel, eg, Channel 7 or so, which is hopefully less crowded than default Channel 1; a tool like Netstumbler shows the channels that any bothersome neighbours are occupying. Each connected WiFi device then needs a key inputting that you create during setup. In some routers, timeslots can be set up to turn the wireless service on or off automatically, and buried in its setup the Billion has a daily/ hourly timetable 'spreadsheet' for this.

That's all for this month – remember you can discuss with fellow readers in our forum at **www.chatzones.co.uk** or write to us at **editorial@epemag.co.uk**

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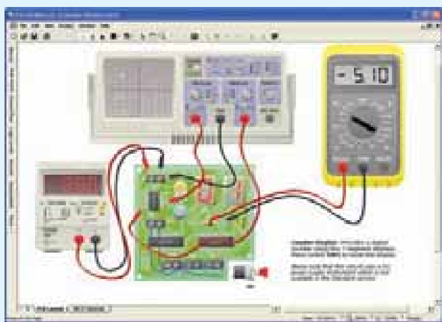
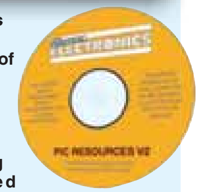


This is the software used in our *Teach-In 2011* series.
Standard **£61.25** inc. VAT
Professional **£91.90** inc. VAT

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 2000/ME/XP, mouse, sound card, web browser.

EPE PIC RESOURCES V2



Version 2 includes the EPE PIC Tutorial V2 series of Supplements (EPE April, May, June 2003)

The CD-ROM contains the following Tutorial-related software and texts:

- EPE PIC Tutorial V2 complete series of articles plus demonstration software, John Becker, April, May, June '03
- PIC Toolkit Mk3 (TK3 hardware construction details), John Becker, Oct '01
- PIC Toolkit TK3 for Windows (software details), John Becker, Nov '01

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READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

☆ LETTER OF THE MONTH ☆

PIC data to PC spreadsheet

Dear Editor

In a recent *Readout* letter, Bob White asked about how to get data captured in a PIC into an Excel spreadsheet using a serial or USB link. I have recently done this, and can provide what I think is a solution that works well and requires very little software to be loaded on the PC. A full listing of the assembler code that I used on my PIC is attached. (*Please email the office for the file – editor*)

The concept is to format the logged data as a comma-separated file in the PIC, and send this to the PC using a UART connection into a terminal emulation program, such as HyperTerminal. The data is copied out of the terminal emulation buffer on the PC screen and pasted into Notepad, where it is saved as a text file.

(Note, HyperTerminal and Notepad are standard programs that come with all versions of Windows, and will be found in the 'All programs/Accessories' folder).

You then open Excel, and from within Excel open the saved text file. Excel will launch the text import wizard, where you can tell it that you have a delimited file and that the delimiter is a comma and the data format is 'General' (the default). It will then import the data into Excel and you can process it or produce graphs as you wish.

So, how do you produce a comma-separated file on a PIC and send it using the UART? Well, a comma-separated file has the data represented as numeric text characters, with a comma between each data item and a new line character at the end of every set of data.

For example, if you wanted to send a set of data representing the desired position of a servo, and the actual position of the servo every 50 milliseconds, then you might produce a stream of data such as 000,000 nl 005,006 nl 010,012 nl 50, 60 nl, 100,120 nl. This represents five sets of data, each with two values and each terminated by the new line (nl) character.

When you collect the data, it will be in the form of 8-bit bytes or 16-bit words in binary. So before you send it you need to convert these into a string of three or five numeric text characters.

Bob doesn't mention what PIC he is using, but I am using a dsPIC, which is a 16-bit processor. Therefore, I am logging and sending 16-bit data values as five numeric characters to the PC, but the code could be easily reduced to send only three characters if you are using 8-bit data values.

My netbook PC has no serial port, so I am using the FTDI TTL-232R-PCD TTL to USB serial converter board to get the UART on my PIC to talk to the PC. Note that there are two versions of this PCB – one for 3.3V signals and one for 5V. If you choose this method, select the one that matches your PIC's power supply voltage. Go to **www.ftdichip.com**, where you will see what variants of the PCB are available and also be able to download the driver for your operating system, which is the only software that will need to be loaded onto your PC.

Code has been included for setting up the UART, logging the data into an area of RAM on the PIC and for sending it to the PC.

A couple of final points. The routine adds one extra data item to the start of each set, which is the number of the dataset being sent. And don't forget to set the speed in HyperTerminal to 19200 and parity bits to match that being sent by the PIC when you set up the connection.

As a long time reader of *EPE* magazine, I'd just like to say: 'keep up the good work'.

David Hannaford, Warwickshire

Many thanks David, that is a most useful answer to Bob's question, and doubtless a handy technique for many data-collecting PIC project builders.

Sourcing sodium hydroxide

Dear Editor

I was interested to read Robert Scott's article on UV light boxes in the Aug '10 issue. I have also built a home-made box, but using a commercial time switch, and with an alarm when time is up.

With regard to obtaining sodium hydroxide, I find it is available (under the name 'caustic soda') from my local branch of Boots. It is in the household section because it is used for unblocking drains. It might also be worth trying hardware stores.

I use it at 8% strength to remove the resist after etching, and it works fine. I have not tried it as a developer, but according to Bill Mooney's book on surface-mount devices, it should be used at 1.6% for commercial pre-coated PCBs, and 1.2% for home-coated boards. The percentages are weight/volume – that is 16 or 12 grams per litre.

Sebastian Linfoot, Oxford

Good tips there Sebastian – thanks. And as always, readers must treat chemicals, including caustic soda, with great respect – always follow the instructions.

Waste not want not

Dear Editor

Following on from previous suggestions for worthwhile recycling, here are two items that are often discarded, but which usually have some useful components.

Microwave ovens have a plethora of small items and a very heavy transformer. However, the most useful part is the magnetron assembly. Remove all the cooling fin metal work and the magnetron has a pair of annular magnets fitted to it to supply the magnetic field when in use. These are very powerful and when removed have a multitude of uses. In winter, four of them hold a waterproof cover over my car.

Disposable cameras with flash should never be handed over complete when all the film has been exposed. Remove the film cassette and pass this to the photo shop. The plastic case can be opened fairly easily to remove an AA battery. During its use to power the flash very little of its charge will have been used and there is plenty of life left in it. There is a PCB which, when powered by a single AA battery, provides a 300V power source. This is used to charge an electrolytic capacitor, which supplies the energy for the flash tube. At the side of the board, the contacts needed to flash the tube are easily located. The power source has many other uses when a low-power, high-voltage source is needed.

Guy Selby-Lowndes, Billingshurst

I like the magnet use Guy. Readers must ensure that mains-powered machinery is truly dead before poking around inside! Microwave ovens, like CRT televisions, can store high voltages in capacitors long after they have been switched off. If in doubt, seek help and advice from a qualified expert.

DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

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Electronics Teach-In 3

FREE CD-ROM

The three sections of this book cover a very wide range of subjects that will interest everyone involved in electronics, from hobbyists and students to professionals. The first 80-odd pages of Teach-In 3 are dedicated to *Circuit Surgery*, the regular *EPE* clinic dealing with readers' queries on various circuit design and application problems – everything from voltage regulation to using SPICE circuit simulation software.

The second section – *Practically Speaking* – covers the practical aspects of electronics construction. Again, a whole range of subjects, from soldering to avoiding problems with static electricity and indentifying components, are covered.

Finally, our collection of *Ingenuity Unlimited* circuits provides over 40 different circuit designs submitted by the readers of *EPE*.

The free cover-mounted CD-ROM is the complete *Electronics Teach-In 1* book, which provides a broad-based introduction to electronics in PDF form, plus interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In 1 series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In 1 series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC. There is also a MW/LW Radio project in the series.

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PROJECT CONSTRUCTION

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R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

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This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

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This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

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104 pages — **Order code BP248** — **£4.49**

COMPUTING

ELECTRONICS TEACH-IN 2 CD-ROM

CD-ROM

USING PIC MICROCONTROLLERS A PRACTICAL INTRODUCTION

This *Teach-In* series of articles was originally published in *EPE* in 2008 and, following demand from readers, has now been collected together in the *Electronics Teach-In 2* CD-ROM.

The series is aimed at those using PIC microcontrollers for the first time. Each part of the series includes breadboard layouts to aid understanding and a simple programmer project is provided.

Also included are 29 *PIC N' Mix* articles, also republished from *EPE*. These provide a host of practical programming and interfacing information, mainly for those that have already got to grips with using PIC microcontrollers.

An extra four part beginners guide to using the C programing language for PIC microcontrollers is also included.

The CD-ROM also contains all of the software for the *Teach-In 2* series and *PIC N' Mix* articles, plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Micrcontrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

CD-ROM — **Order code ETI2 CD-ROM** — **£9.50**

COMPUTING FOR THE OLDER GENERATION
Jim Gatenby

Among the many practical and useful ideas for using your PC that are covered in this book are: Choosing, setting up and understanding your computer and its main components. Writing letters, leaflets, invitations, etc., and other word processing jobs. Keeping track of your finances using a spreadsheet. Recording details of holidays and other ideas using a database. Using the Internet to find useful information, and email to keep in touch with family and friends. Making 'back-up' copies of your work and checking for viruses. How to use Windows XP to help people with impaired vision, hearing or mobility.

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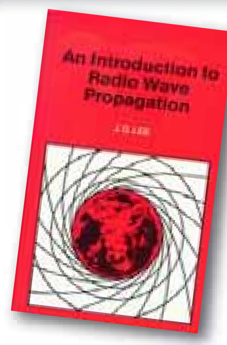
RADIO



AN INTRODUCTION TO RADIO WAVE PROPOGATION
J.G. Lee

Radio wave propogation is one of the more important discoveries made in the early 20th century. Although technology lagged behind early experimenters pursued this newly discovered phenomenon eagerly for, in understanding the physics of propagation, they were discovering more about our Universe and its workings.

Radio wave propagation has its origins in the world of solar physics. The Sun's radiation provides the mechanism for the formation of the ionosphere. How the ionosphere is formed, and how it provides long-distance communication, is carefully explained. Non-ionospheric propagation, including 'moonbounce' or satellite communications, is covered as well.

This book has been written with the average electronic hobbyist in mind. Technical language and mathematics have been kept to a minimum in order to present a broad, yet clear, picture of the subject. The radio amateur, as well as the short-wave listener, will find explanations of the propogation phenomena which both experience in their pursuit of communications enjoyment.

116 pages — **Order code BP293** — **£4.45**

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THEORY AND REFERENCE

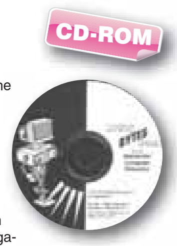
BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (call me Max) Maxfield

This book gives the "big picture" of digital electronics. This in-depth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

470 pages **Order code BEB1** **£35.99**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown



This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

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INTERFACING PIC MICROCONTROLLERS
Martin Bates

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Interfacing PIC Microcontrollers provides a thorough introduction to interfacing techniques for students, hobbyists and engineers looking to take their knowledge of PIC application development to the next level. Each chapter ends with suggestions for further applications, based on the examples given, and numerous line drawings illustrate application of the hardware.

Step-by-step examples in assembly language are used to illustrate a comprehensive set of interfaces, and these can be run interactively on circuit simulation software, used to aid understanding without the need to build real hardware.

A companion website includes all examples in the text which cam be downloaded together with a free version of Proteus's ISIS Lite.

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

102 pages **Order code BP239** **£5.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. SInclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

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Ian Waugh

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All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

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R. A. Penfold

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The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

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VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

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Keith brindley

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Robert Goodman

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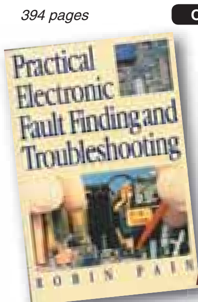

PIC IN PRACTICE (2nd Edition)
David W. Smith

A graded course based around the practical use of the PIC microcontroller through project work. Principles are introduced gradually, through hands-on experience, enabling hobbyists and students to develop their understanding at their own pace. The book can be used at a variety of levels.

Contents: Introduction to the PIC microcontroller; Programming the 16F84 microcontroller; Introductory projects; Headers, porting code – which micro?; Using inputs; Keypad scanning; Program examples; The 16C54 microcontroller; Alphanumeric displays; Analogue to digital conversion; Radio transmitters and receivers; EEPROM data memory; Interrupts; The 12 series 8-pin microcontroller; The 16F87X microcontroller; The 16F62X microcontroller; Projects; Instruction set, files and registers; Appendices; Index.

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PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING
Robin Pain

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Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.

The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.

274 pages **Order code NE22** **£41.99**

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R. A. Penfold

Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

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AUDIO AMPS

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Morgan Jones

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Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

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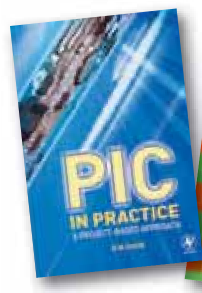

circuit operation and a stripboard layout diagram. All constructional details are provided along with a shopping list of components, and none of the designs requires the use of any test equipment in order to set up properly. All the projects are designed for straightforward assembly on simple circuit boards.

Circuits include: High impedance mic preamp, Low impedance mic preamp, Crystal mic preamp, Guitar and GP preamplifier, Scratch and rumble filter, RIAA preamplifier, Tape preamplifier, Audio limiter, Bass and treble tone controls, Loudness filter, Loudness control, Simple graphic equaliser, Basic audio mixer, Small (300mW) audio power amp, 6 watt audio power amp, 20/32 watt power amp and power supply, Dynamic noise limiter.

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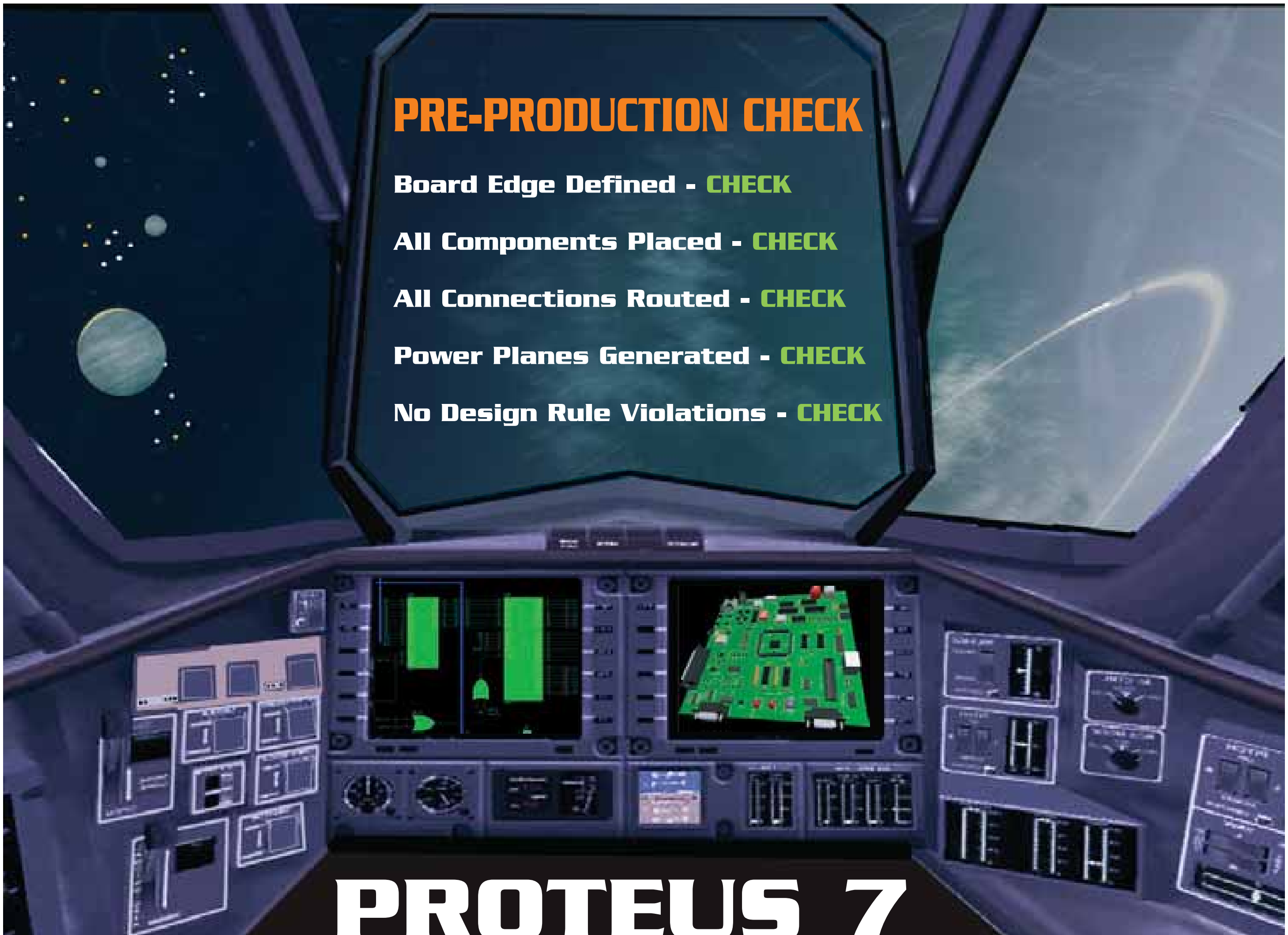
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